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# ANALYSIS OF NASA POSTCARD SUBCONTRACT DATA
(NGR- 05-007-047)

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# Preface

This report covers research done at the Institute of Government and Public Affairs under NASA Research Grant, NGR-05-007-047. The subject matter of the research undertaken is a furtherance of two mutual interests of the Institute and the National Aeronautics and Space Administration, namely: (1) the differential impacts of civilian space activity on the various subnational areas of the United States and, (2) the improvement of data collection and processing for such analyses. The two are reverse sides of the same coin.

The author, as is customary, assumes responsibility for the content of the report. Acknowledgement is in order to Mr. S. A. Sawmelle, Chief, Reports Branch, Special Inquiries and Reports Division, Office of Procurement, NASA Headquarters, Dr. Werner Z. Hirsch, Director, Institute of Government and Public Affairs, Dr. Sidney Sonenblum, Institute of Government and Public Affairs and the National Planning Association, for their aid in carrying through the study. Special thanks must be given to Mrs. Lyda Boyer for her skill in transforming the report into readable form.

## Introduction

Americans have always tended to be a factual-minded people, and economic and social fact gathering has long been embodied in governmental operations. This attitude is reflected in the growth of data concerning the economic and social structure of the country. The growth of such information, as disseminated by public bodies, has been influenced by two considerations: first, the obligation of the government to base public policy on factual information, and, second, the obligation of the government to provide basic information to private individuals for guidance in their personal and business affairs.

Apart from such agencies as the Bureau of the Census and the Office of Business Economics (both U.S. Department of Commerce), and the Bureau of Labor Statistics, the government's statistical activities tend to be by-products of its administrative, regulatory, or executive functions. The social and economic data generated by the National Aeronautics and Space Administration is a by-product of its acquisitions of space systems. The information base is oriented towards internal management, control, and planning. Although NASA generated data are designed mainly to assist its own management, the same data can meet many needs of its suppliers, the aerospace industrial complex, since the same "alphabet" can be used in communication. The same body of data can also meet some needs of the researcher concerned with regional and social impacts of space activities. There are many limitations, however, for both groups. Since—with few exceptions—NASA data are derived from operational and fiduciary needs, the basic data requirements for broad socio-economic analyses have not been incorporated into the information systems' design. This lack may be attributable to the space agency's hardware orientation in fulfilling its space mission.

NASA data are conceived as running along with the technological and hardware developments as inputs into NASA management as the space context evolves. The space context, however, is more than the selected missions. It is comprised of political, economic and social aspects as well as those that are strictly space, in the narrow sense.

Space system acquisition activities start with or are implied by national goals and objectives. The broad national goals must, by necessity of achieving widespread acceptance, be rather abstract. The broad goals that are the basis of civilian space activity are summarized in the first section of this report. When the implementation of broad goals begins with operational programs, means and ends must be more specifically defined; this narrowing often results in conflicts.

That there are regional differences and regional economic conflicts in the United States is a historical and accepted truism. NASA finds itself involved in this conflict, through both its intra- and extramural activities. The first section of this report includes a discussion of the ways by which NASA affects regions and why regions compete for space technology tasks. This discussion is followed by comments on the instruments through which NASA may affect geographic areas.

That there are regional conflicts in the nation, that geographic units compete for contracts, and that data are needed to indicate NASA regional impacts, is not news to the space agency. As a matter of fact, NASA has pioneered in data collection on regional flows through its subcontractor reporting system—the so-called "postal card system." The central part of the UCLA effort is a review of this postal card system followed by analyses using information derived from it.

A review of the subcontractor data system, in the second section, was a prerequisite for its use in analyses. In sections three and four the results of some analytical applications are discussed. As in the case of the data review, the applications necessitated going beyond the subcontractor data and integrating this body of information with other data, both NASA and non-NASA generated. Because of data limitations, discussed in the data review section, the analyses are designed more for profile tracing than detailed depth analyses. Due to these limitations the study could not incorporate some geographic and industrial network analyses originally planned. The analytic results yield little that may be classified as startlingly new. What does emerge is the need for better and improved data and a deeper probing.

In the fifth section, two things are attempted: first, a preliminary design is established for the information output requirement to study regional implications of NASA programs. Secondly, a methodology is developed for linking conjectures on regional impacts with alternative future NASA outlays; that is, to integrate specific types of economic data on past programs into the NASA planning-programming-budgeting system. If successfully done, additional economic information would enter the decision process.

The final section of the report covers suggestions for improving NASA's economic fact gathering. Again, major emphasis is on the subcontractor reporting system. There are monetary costs involved in gathering information; there are also nonmonetary costs to NASA derived from changes in the information collected such as changes in the means and links of communication and in organization (for example, reorganizations of computer centers). The former costs may be measured, but the latter are, on the whole, not measurable. The costs and benefits from any recommendation or suggestion made here can only be calculated by the space agency. In this case the metric for choice comes from internal pressures and bargaining.

## I. THE NASA MISSION AND ITS REGIONAL IMPLICATIONS

Whether by design or not, virtually all Federal policies and programs will have differential impacts on regions as a consequence of regional differences in resource endowment, size, and characteristics of population and income. This is so whether such Federal policies are implemented through procurement, transfer payments, taxation, or grants-in-aid. The prominent place occupied by the North-South tariff controversy in United States history reminds us that these differential impacts have always been present and have generally been recognized.

These differential impacts can give rise to two sorts of conflicts. First, there is the conflict among regions competing for limited Federal funds. Second, there is the conflict between regions and the Federal Government; the Federal agencies claim that they should not be diverted from efficiency in achieving their primary objectives by considerations of regional impacts, and regions counter that geographic impacts should be considered in programmatic choices and evaluations.

With an annual budget of over $5 billion NASA has been a prime focal point for such conflicts. Whatever the motivations for establishing the space agency, its use as an instrument for differential regional economic growth was not an overt one. Nevertheless, NASA is deeply involved in important interregional controversies centering about the conflict situations mentioned above and on the geographic distribution of Federal funds for science and technology. The nation (and its public and private decision makers) has learned that expenditures on basic and applied science and technology not only helps science and national security, but such outlays contribute to the current and potential welfare of the various regions where they are made. Consequently, through its science and technology activities, NASA is an important change agent.

In the short run, the effect of NASA activities on employment and income is significant; while, in the long run, the important consideration is the way a region's capacity for growth is affected by the continuing distribution of Federal funds for science and technology. In either case there is pressure on a mission oriented agency to consider nonmission activities in deciding where to procure, where to place its installations, and where to support basic science.

These factors are germane to a discussion of utilization of space agency data for regional implications. The basic questions of data for whom, for what purpose, and the relationship of information systems to organization will be explored elsewhere in this report. In this section our concern is with NASA's objectives and their relationship to regional conflicts and with the conceptual mechanism of regional impacts and economic growth.

## Space Agency Objectives

The National Space Act of 1958 (Public Law 85-568), establishing NASA, enumerates the objectives of the space program of the United States and of NASA in particular. In accord with these objectives and subsequent policy documents issued by appropriate officials, the major responsibilities of NASA can be summarized as follows:

"1. Development and operation of spacecraft and of the required ground support systems for manned and unmanned flight in space.

2. Exploration and investigation in space with these manned and unmanned spacecraft to gain scientific knowledge, to further our understanding of the universe, and to

gain engineering knowledge for profitable use of the space environs.

3. Application of the results of these space explorations and investigations to the general welfare of mankind and to the protection of our national interests.

4. Contribution, in a major way, to the general advance of science and technology within the United States to ensure the appropriate posture of the United States in science and technology within the community of nations."[1]

To implement the national policy that "activities in space should be devoted to peaceful purposes for all mankind" the Act specifies that the space program should be directed by a civilian agency, the National Aeronautics and Space Administration. The immediate goal was symbolized by President Kennedy in 1961 when he announced the nation's intention of "landing a man on the moon and returning him safely to earth."

Consequently, with policy goals and objectives laid out, the major thrust of NASA spending is to support the development of science, technology, and "hardware," oriented to the operations selected to achieve the above goals. To achieve the broad consensus often necessary for action, public goals are usually stated in generalized and lofty terms. They are often ex post statements—the 1958 Space Act was a reaction to the "sputnik incident." How much weight should be given to official goals is a matter of personal judgment.[2]

It is difficult to mount a public consensus against science, defense, and national prestige. As a justification for a national

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1. Addison M. Rothrock, "Long-Range Planning In The National Aeronautics and Space Administration," George A. Steiner (Editor), Managerial Long-Range Planning (New York: McGraw-Hill Book Co., Inc. 1963) pp. 274-75.

2. See Vernon Van Dyke, Pride and Power (Urbana, Illinois: University of Illinois Press, 1964).

space program the above goals carried considerable weight. Implicit in them, however, are the short-range impacts on income and employment and long-range implications of new technologies. There are dissenting voices on the relative allocation of resources to space activities, specifically as to the lunar program. Some look at the opportunity costs of specialized resources preempted by NASA—that is, the alternative uses of scientists and engineers—and conclude that the social costs outweigh the gains.[3] Since the evidence for this point of view is decidedly inconclusive, there are strong counter-arguments.[4]

The previous considerations deal in a large part with the allocation of scientific resources. The allocation of these resources between NASA space activities and other Federal activities, (especially those in health, education, and welfare) is becoming increasingly important as the Federal budget constraints tighten. New Federal budgetary processes such as program budgeting are being developed to assist in rationalizing Federal programmatic decisions. These processes are aimed at evaluating the relative costs and utilities of alternative resource allocations. Given the current state of the art of evaluation, such approaches are not likely to result in quantitative measures comparing the relative net social worth of the output of

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3. See Amitai Etzioni, The Moon-Doggle (New York: Doubleday, 1964), and Edwin Diamond, The Rise and Fall of the Space Age (New York: Doubleday, 1964).

4. See Richard S. Rosenbloom, Technology Transfer-Process and Policy, (Washington, D.C.: National Planning Association, 1965).

space and nonspace programs. What this means is the nation will continue to judge the relative merit of space versus nonspace programs through the Congressional process as space payoffs appear. However, more sophisticated program evaluations may well increase the pressures on NASA to consider socio-economic consequences in its programmatic decisions.

Geographic Distribution of Federal Funds for Science and Technology

The arguments between the "have" and the "have not" subnational areas on the distribution of Federal outlays for science and technology cover the entire spectrum of activity, from basic research to procurement and subcontracting. Many Federal agencies are involved, from the basic research-oriented National Science Foundation to the mission-oriented Department of Defense and the National Aeronautics and Space Administration. A belief is held at local levels that, in some way the "marketplace" works imperfectly, resulting in an "unfair" areal distribution of funds for science and technology. Consequently, each geographic unit attempts to change the rules of the game in order to obtain its "fair share."

The core of the controversy centers about the relative importance assigned to short term economic efficiency in resource allocation and to the long-run social and economic implications of expenditures for science and technology: the economic efficiency argument is that awards should be made to those firms, technical units, or institutions, wherever located, that can produce the desired results at the least cost, or, conversely, the most benefits at a given cost. An alternative is that procurement awards should be made with those units giving credible evidence that system performance characteristics and reliability standards can be achieved within the time schedule set and at sufficiently low cost, given technological and mission uncertainties. This efficiency criterion has been, and remains, the predominant rule for the mission-oriented agencies.

The alternative orientation emphasizes the fact that the location of scientific activity, or the production of sophisticated weapon or space systems, has long-run social effects upon the area involved, especially upon the pattern of economic growth; that the social benefits of such public outlays for nationally determined ends should be widely dispersed as a matter of public policy; and, that any short-run inefficiencies leading to increased systems cost will be overcome by the long-run social benefits and social cost savings, or, if not overcome, are socially acceptable in the light of equity considerations.

Harry G. Johnson, in commenting upon basic research, forcefully stated this position in the following way:

> "In conclusion, it seems desirable to draw attention to a facet of policy towards basic science that is important but tends to be overlooked by scientists. This is the implication of the geographical distribution of science support for the pattern of growth of the U.S. economy. The location of scientific research activity in a particular city or region generally constitutes a focal point for the development of science-intensive industries in the surrounding area, and this should be taken into account in deciding on the location of such scientific activity. There is a natural tendency for scientific activity to agglomerate around established centers of scientific accomplishment; and this is probably the most efficient way of conducting scientific research from the point of view of science itself. From the economic and social point of view, however, and perhaps even from the longer run scientific point of view, there is a strong case for encouraging the development of scientific research centers in the more depressed and lower income sections of the country, as a means of raising the economic and social level of the population in those sections. Much of the poverty problem is associated with geographical concentration of high-income industries in certain areas and their absence from others, which makes migration the only feasible

route to economic improvement. A deliberate policy of locating scientific research in the backward areas of the country to encourage their industrial development could in the long run provide a socially and economically more attractive attack on the poverty problem than many of the policies now being applied or considered."[5]

But the space agency does not enter into contractual relationships with geographic units. It enters into relationships first with firms, headquartered at a specific point in space, which in turn, are composed of establishments (technical units) which may be co-located, or, in the case of a multi-establishment firm, may be distributed in various geographic locations. In theory, at least, the location of the individual unit is influenced by the comparative advantage of the areal locus for that type of economic activity, that is, on efficiency grounds.[6]

In our Federal system, Congressional representation has a geographic basis. It is through this geographic specificity that influence on the areal distribution of Federal originated spending decisions is brought to bear as the subnational units seek their "fair share." In relation to NASA policies, the state congressional delegations are the chosen instrument for influencing the geographic distribution of fundings. Through such influence each region seeks to gain in its

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5. Harry G. Johnson, "Federal Support of Basic Research: Some Economic Issues," Basic Research and National Goals, A Report to the Committee on Science and Astronautics, U.S. House of Representatives, by the National Academy of Sciences, (Washington, D.C.: U.S. Government Printing Office, 1965), p. 140.

6. By comparative advantage is meant the production of a specific commodity at lowest marginal cost.

comparative advantage through Federal intervention; this sometimes results in a "beggar thy neighbor" policy.

Some Aspects of NASA Generated Employment

Activities funded by NASA are attractive to local areas. In addition to providing income and employment advantages for local residents, the "aerospace and electronic industries" are "clean" industries, that bring skilled, educated, highly paid people to the area; many auxiliary service industries have similar characteristics.

Space and defense contracts are often just lumped together, especially in the regional competition for aircraft, missile, space, and electronic contracts. NASA's budget is predominate in Federal spending for space efforts. In the 1955-1966 fiscal year period, Congress gave new obligational authority of about $34 billion to various agencies for space programs. Of this about 67 percent was allocated to NASA, about 29 percent to the Department of Defense, with the remaining four percent going to the Atomic Energy Commission, the Weather Bureau, and the National Science Foundation. (See Table 1.) The amounts involved are substantial. Not only is NASA predominant in funding, but spends a larger fraction of its budget for purchases from business than the Department of Defense does.

As will be discussed in a subsequent section of this report, it is not feasible, from published NASA generated data, to trace its expenditure impact on employment at a particular unit of time for a particular area. Partial information for determining national and regional employment impacts is contained in the U.S. Bureau of the Census, Census of Manufactures, 1963, Shipments of Defense-Oriented Industries

Table 1

Space Activities of the United States Government
New Obligational Authority, 1955-1966

(in millions of dollars)

| Fiscal Year | Agency: NASA | Dept. of Defense | AEC | Weather Bureau | NSF | Total |
|---|---|---|---|---|---|---|
| Historical | | | | | | |
| 1955 | 56.9 | 3.0 | - | - | - | 59.9 |
| 1956 | 72.7 | 30.3 | 7.0 | - | 7.3 | 117.3 |
| 1957 | 78.2 | 71.0 | 21.3 | - | 8.4 | 178.9 |
| 1958 | 117.3 | 205.6 | 21.3 | - | 3.3 | 347.5 |
| 1959 | 268.9 | 489.5 | 34.3 | - | - | 792.7 |
| 1960 | 461.5 | 560.9 | 43.3 | - | 0.1 | 1065.8 |
| 1961 | 928.7 | 813.9 | 67.7 | - | 0.6 | 1810.9 |
| 1962 | 1796.8 | 1298.2 | 147.8 | 50.7 | 1.3 | 3294.8 |
| 1963 | 3626.0 | 1548.1 | 213.9 | 43.2 | 1.5 | 5432.7 |
| 1964 | 5046.6 | 1604.1 | 210.0 | 2.8 | 3.0 | 6866.5 |
| 1965 Budget | | | | | | |
| 1965 | 5179.8 | 1546.7 | 236.0 | 15.4 | 3.1 | 6984.0 |
| 1966 | 5181.6 | 1670.2 | 225.2 | 33.1 | 3.8 | 7113.9 |
| Total | 22815.0 | 9841.5 | 1227.8 | 145.2 | 32.4 | 34061.9 |
| Percent | 67.0 | 28.9 | 3.6 | 0.4 | 0.1 | 100.0 |

Source: "Report to the Congress from the President of the United States, United States Aeronautics and Space Activities, 1964," National Aeronautics and Space Council, Washington, D.C., p. 156.

Special Report MC63(S)-2.[7] In the Census survey, government business consists of products shipped to, or receipts for work done for, Federal agencies, their contractors, subcontractors and suppliers. The government total is further subdivided into shipments or receipts involving (1) government prime contracts and (2) other manufacturers in ultimate performance of Federal Government contracts. The data are not comparable to NASA generated data used below.

The Census report specified shipments of about $2,565 million to NASA in calendar 1963. Of this about $2,051 million was in prime contracts and $513 million in subcontracts.[8] On the basis of other Census data the $2,565 million represents average output of approximately $20,000 per man-year, or, conversely, 50 man-years per $1 million. Utilizing these rough averages, total reported employment generated approximately 125,000 man-years direct employment.[9]

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7. This report summarizes a special survey covering approximately 30 four-digit manufacturing industries and was financed by the National Aeronautics and Space Administration, the Department of Defense, and the Atomic Energy Commission. Selected nonmanufacturing facilities of the manufacturing companies canvased in the sample survey were also included.

8. The subcontract figure is a low estimate for two reasons: (1) the 30 industries covered do not include basic materials and general component industries, and (2) due to inadequate instructions companies having prime contracts usually reported interplant transfers as prime contracts rather than subcontracts. The $2,565 million represents the sample universe inflated in accordance with their sample weights in the 1962 Annual Survey of Manufactures. No employment figures are given for this value.

9. The weighted average here represents duplicated production since subsystems and components may be counted twice in the aggregation, once in the establishment where fabricated, and again as part of the final product.

It is not surprising that the direct employment generated per dollar expended in the selected manufacturing industries is low relative to other manufacturing activities. Space systems require skilled manpower and high degrees of fabrication, not raw materials. The average wage and salary in the combined aerospace and transit equipment sector,[10] as reported in the 1963 Census of Manufactures, is $7,525 in contrast with an average of $5,585 for all other manufacturing. Also, the combined aerospace and transit sector has a significantly higher ratio of nonproduction workers to total employees, 40 percent as compared with 25 percent for all other manufacturing. The relatively high wage and salary payments also imply a relatively high value added and a relatively low cost of material ratio, i.e., cost of materials to value of shipments. The cost of raw materials—semi-fabricated goods, and services—purchased outside the combined sector are approximately 40 percent of receipts. (This 40 percent can be interpreted as the value of all subcontracts, broadly defined, awarded outside the sector.)[11]

The 1963 distribution of NASA manufacturing employment is unevenly distributed over the various regions of the nation. (See Chart 1) The current distribution most likely would not markedly

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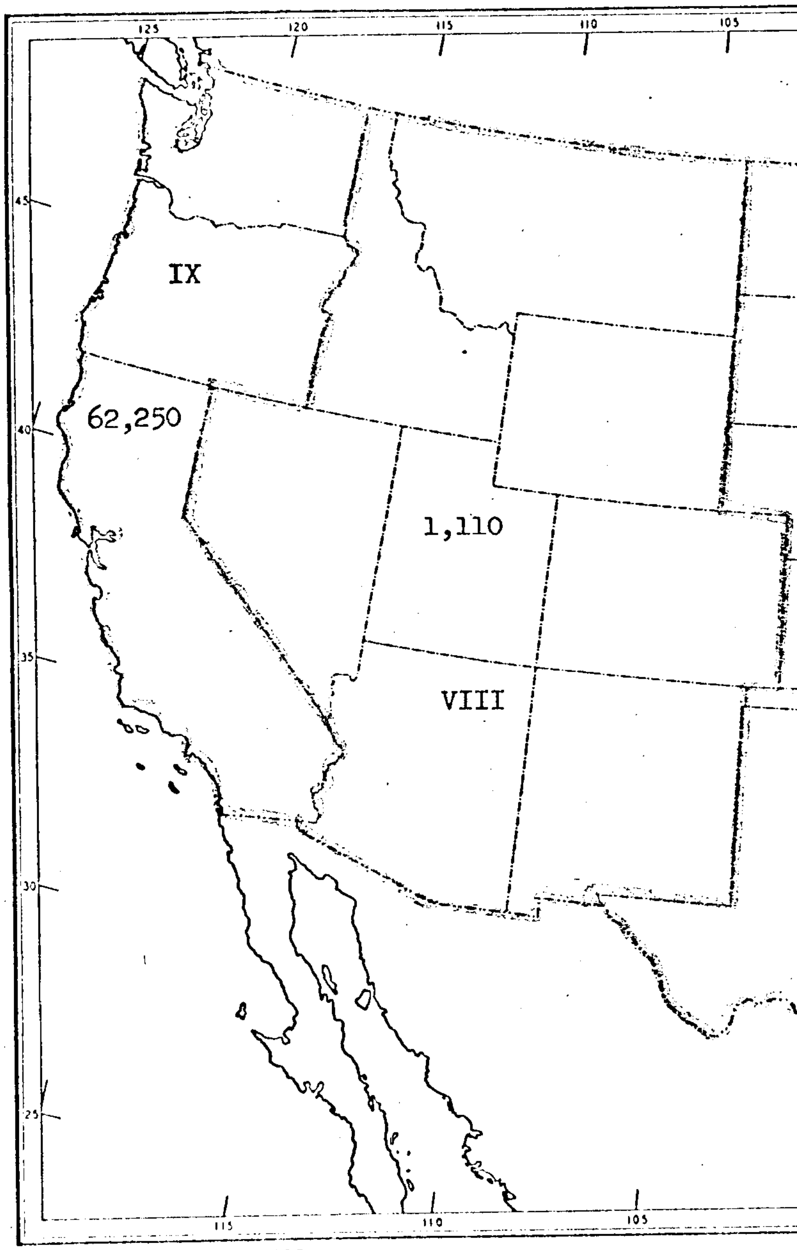
10. Includes the following four-digit industries: aircraft, aircraft engines and parts, aircraft propellors and parts, aircraft equipment, n.e.c., and guided missiles and space vehicles, completely assembled.

11. The 40 percent generates additional production and employment to suppliers, who in turn purchase goods and services, and so on in a diminishing series. These so-called indirect production effects might add another 50-60 percent to the 125,000 direct man-years generated.


I -- New England
II -- Mid-Atlantic
III -- East-North Central
IV -- West-North Central
V -- South Atlantic
VI -- East-South Central
VII -- West-South Central
VIII -- Mountain
IX -- Pacific

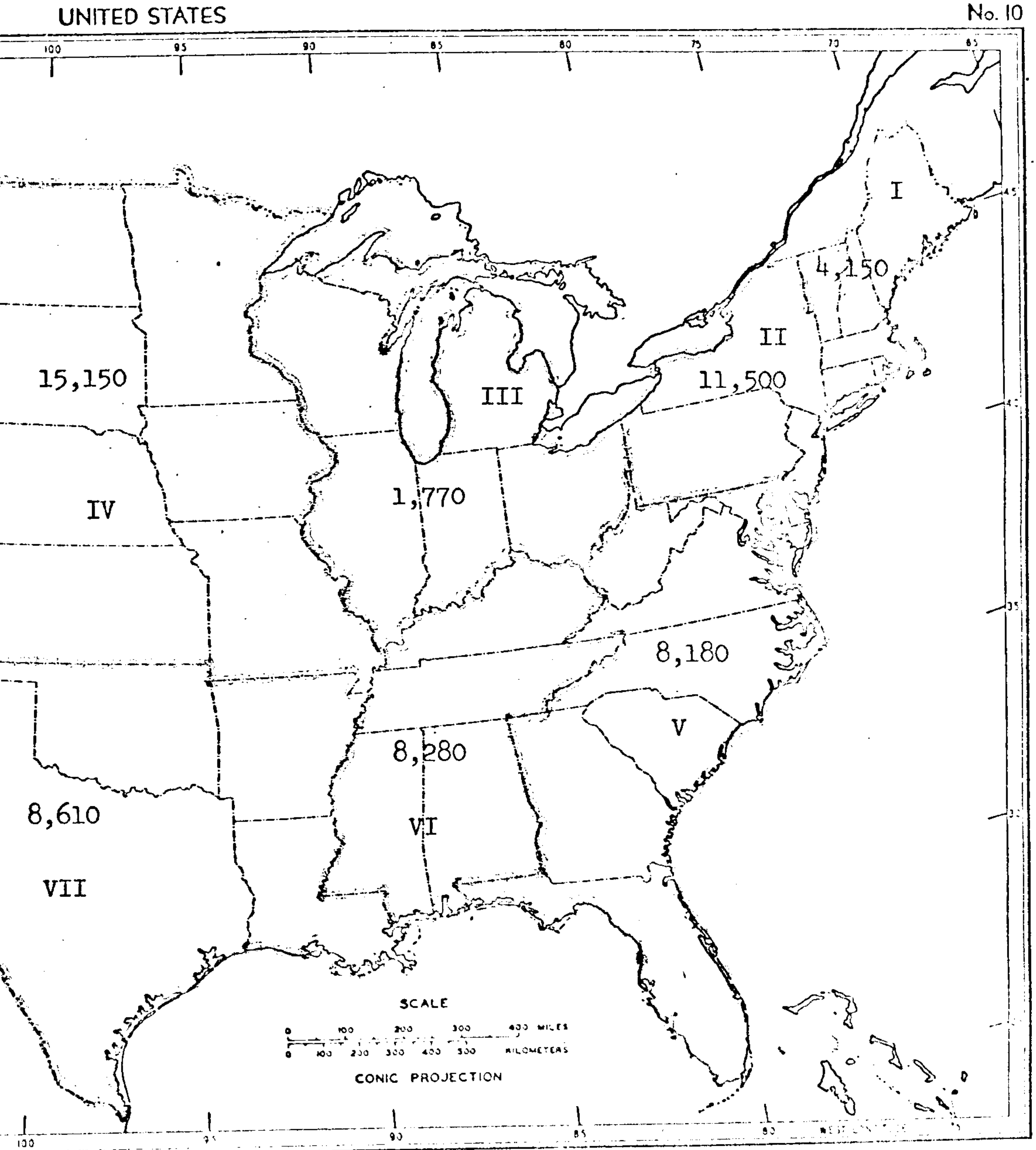

GOODE'S SERIES OF BASE MAPS

1. Includes employment in some selected non-manufacturing facilities of manufacturing facilities canvassed. Reported data: not inflated.

1-12-1

Chart 1

ted Employment In Manufacturing
stries, By Region, 1963 [1]




Source: Based on data in Special Report MC63(S)-2
Shipments of Defense-Oriented Industries
U.S. Bureau of the Census, Washington, D.C.
Mar. 1966, Tables 4 and 7.

1-12-2

differ in this respect from 1963. The civilian space effort in manufacturing is predominantly performed west of the Mississippi. Roughly 80 percent of the 121,000 total employment reported by the Census is located there.[12] Slightly more than 50 percent of the total is found in the Pacific region. There is also increasing employment in newer manufacturing states such as Louisiana, Florida, and Missouri. The important manufacturing centers in the East-North Central states—Ohio, Indiana, Illinois, Michigan, and Wisconsin—barely surpass the mountain states in civilian space effort. This unequal distribution, and the trend toward newer centers of manufacturing activity, is not necessarily evidence that the allocation of space funds is following efficiency criteria. The distribution is partially due to the drive of the "have not" states to influence Federal allocations of research and development funds to include geographic spreading out as one criterion.

Some Conceptual Aspects of Regional Growth

There are good reasons for regional polities to be concerned about, and to emphasize, regional economic growth. Adequate growth provides a suitable base for a region to grapple with its problems of income stability, fiscal health, and equity for its residents. Income stability covers the goal of maintaining high levels of employment and income; fiscal health, with provisions for an adequate tax base for providing the necessary public services; and, equity,

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12. The 121,000 total employment reported in the Census survey represents covered data and is not inflated as described in footnote 8. It is consistent with receipts of $2,417 million. The regional distribution is estimated by UCLA from partial data in the survey.

with the distribution of income, public services, taxes, and burdens.

But differential regional growth is characteristic of our open, highly dynamic economy. For example, between 1950 and 1960 about one-half the approximate 3,000 counties in the United States lost population. The elements that are central to national economies tend to perform similar roles in specific regions. Among these are the role of natural and human resource development, the quantity and quality of social overhead capital, entrepreneurship and the ability to innovate, and the flexibility to take advantage of technological developments. These characteristics are not uniformly spread over the country.

In addition to these regional development factors, studies underline the important role that "export industries" play in subnational economic growth.[13] As external demands generate employment, profits, and earnings in such industries, a chain reaction of expansion in other industries supplying them and servicing the local market is established. In particular, activity in local trade and service industries is stimulated through the familiar multiplier process.

Another element in regional economic growth is its industry mix; if it is capable of attracting a high proportion of industries whose production and employment can be expected to grow faster than, say, the national average for all industries, we can say that the region is favorably situated (unless rapid growth is accompanied by instability).

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13. An "export industry" is one whose product is shipped outside the boundaries of the geographic unit. On its relative importance, see H. S. Perloff, E. S. Dunn, Jr., E. E. Lampard, and R. I. Muth, Regions, Resources, and Economic Growth, (Baltimore, Md.: Johns Hopkins Press, 1960).

There is no question that space activities—both intramural and extramural—represent both "export" and "growth" categories and are therefore important to a region's development. But, perhaps even more important is the effect of space activity on technological development and its consequences for long term growth.

Technological knowledge is one of the key factors determining output per worker—it limits the kinds of products man knows how to produce and the various processes that he knows for producing them. Such knowledge becomes a constraint to potential output overtime. Economic growth defined as the rate of change in potential output in the future, means a region grows by moving out its production possibility frontier. Thus the impact of technological change can remove a current constraint and provide opportunities for regional adjustments to an enlarged spectrum of alternatives in combining resources in different ways. That is, the aggregative production function changes.

Improvements in technology are known to have been an important element in national growth, but how important is uncertain. There are possibilities that technology might account for an even greater share in the future. However, what is true for the nation is not necessarily true for a specific region; growth in some regions is dependent less on activities incorporating newer and more sophisticated technologies than on their ability to attract industries with relatively older technologies.

Competition for NASA contracts is largely influenced by the view that space technology is a "growth" industry. Whether or not the region would be "better off" to service this growth industry rather than another growth industry, or even a relatively stagnant industry, is rarely calculated.

When we appraise technology not as a growth industry, but in its ability to change the production function to increase output obtained from a given quantity of inputs, then there is a serious question as to whether the location of the firm introducing technological change is a strategic factor in a region's long-term growth. This is because technological improvements are usually not oriented towards improving the efficiency of the resources in a given area; rather, they are oriented towards improved (industry or product) methods of production no matter where the production might take place. Technology which improves the nation's aggregate production function need not improve the aggregate production function in the region where the technological development occurs; indeed if the innovation leads to production occurring in some other area, the "home" region may be relatively worse off.

Because of this the observed relation between regional growth and technological oriented activity in the region must be viewed with some caution. The technology is probably not the cause of the growth, but rather technological activity is attracted to growing areas.

The extent to which technological activity does serve as a crucial factor in regionally differential changes of the aggregate production function probably results from three factors: first, the highly professional personnel which are involved in the technology industry attract other highly skilled persons and insist on an environment conducive to educational and other scientific amenities; second, the organizational know-how developed in the technology industry spills over to other industries in the area; and, third, the technology industry attracts technology-oriented satellite industries.

## NASA Instruments for Affecting Regions

Generally speaking, NASA has four instruments for influencing regional activity and growth:

1. Procurement (including subcontractors)
2. Intramural activities
3. University programs
4. Technology utilization programs.

In establishing a civilian space agency, Congress was well aware of its potentials for nonspace ends. Under the legislation establishing the National Aeronautics and Space Administration, it specifically directed that steps be taken not only to increase the scientific and technical capability of the nation in fields needed for advances in space but also to undertake "long-range studies of the potential benefits . . . and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes." Studies under this directive have enabled NASA to begin an assessment of educational, social, and economic implications of its programs. This is a continuous process, since the implications of much of what the agency has done can only be traced over longer time periods.

## Procurement

About 93 percent of NASA's budget is contracted out with private profit and not-for-profit firms. But competition here means technology competition even more than price competition. The competitive basis for contract awards is broadened to include considerations of scientific and technical capabilities and management competence, as well as systems cost. Most prime contract awards are for the development of space, aeronautical and launch vehicle systems and supporting components. For the most part, it is not feasible to prescribe a detailed technical approach or to define complete specifications for procurement purposes. Change orders and changes in scope of work are commonplace. Consequently, NASA negotiates the preponderant share of its procurement contracts in accordance with statutory authority to negotiate for experimental, developmental, or research work. For fiscal year 1964, about 81 percent of procurement awards were so negotiated. This percentage may change as new policies, such as incentive contracting, are in effect over time.

Although price competition does not operate as freely in this market as in conventional markets, economic efficiency is an important consideration. The agency has budget constraints, and seeks to keep costs down and to minimize overruns. On technical grounds there are four major elements to be considered in systems acquisition: performance characteristics, reliability, time, and costs. Important trade-off decisions are made here and often the ultimate monetary cost is the derived variable.

The allocation of subcontract awards is less under NASA control, except for the subcontracting that occurs when two firms jointly win an award and one of them furnishes subsystems. Aside from agency subcontracting policies such as make-or-buy rules and set-asides for labor surplus areas and small business, NASA has relatively little to say. The make-or-buy decision is an economic one, necessary just because effective price competition is lacking. The other two are deliberate income redistribution policies. Any effective consideration of changing the relative regional impacts of NASA procurement must start with prime contract awards.

NASA Centers and Installations

The agency has approximately 34,000 employees of which slightly over 2,000 are headquarters staff. Compared to other Federal Government agencies, it has about the same employment as the General Services Administration and about 10,000 fewer employees than the Federal Aviation Agency. The type of activity and employee are similar to those in private space firms. However, because the NASA installation is more subject to Congressional scrutiny than agency procurement policy, the intramural affects on regional development probably receive more attention than warranted.

The NASA installation's impact differs geographically. Certainly the social and economic changes started by an installation in Alabama, or Louisiana are different than those started by an installation in California. The Congressional uproar over the proposed location of an Electronic Center in the Boston, Massachusetts, area is ample evidence of the advantages expected to occur to the region in which the Center is located. Part of the competition was due to an effort to lessen the concentration of electronic technical capability in the Boston area and to even out opportunities for potential future regional growth.

University Programs

The NASA sustaining university program in FY 1964 covered about 1,960 students enrolled in 131 different institutions. This training is a long-run investment in human resources to increase the supply of scientists and engineers. (About 4 percent of the 1,960 were enrolled in the behavioral sciences.) Other parts of the sustaining university program cover facilities (provision of required research laboratories) and research to encourage greater university participation in the national space effort. For FY 1964, this program was funded at $40 million, with about 50 percent for training purposes, 30 percent for facilities, and 20 percent for research. In all, about 190 universities are currently working under NASA grants and research contracts. To the beginning of calendar 1966, about 27 institutions had received research facilities grants.

The sustaining university program is not limited to leading institutions, and represents a conscious effort to seek out and develop competence across the nation. The initial regional impact is to bolster the technological potential and raise the quality of skilled workers. Facilities will remain at the universities after the contracts are completed and can attract better students and faculty. But given the mobility of the scientist and engineer, many individuals will likely leave the point of training. The nation is certain to gain, if not the region.

Technology Utilization Program

Communication problems within the space/defense complex is difficult at best, let alone passing on information from space to nonspace activities. The Administrator of NASA has established a technology utilization program "for the rapid dissemination of information . . . on technological developments . . . which appear to be useful for general industrial application."[14] From a variety of sources, including intramural research centers, private contractors, universities, etc., space-related technology is collected and screened; that which is judged to have potential industrial use is made available to the general public.

Technical information has always been an important "factor of production" and a base for industrial growth. The increased complexities of communication in this area have given rise to what Werner Z. Hirsch has characterized as an emergent "knowledge transformation industry," attempting to develop a formal and organized information system for transmitting space related technology.[15]

The question of whether the nation is "getting its money's worth" out of the civilian space program through technological "spillover" to nonspace activities should be a secondary rather than a primary consideration in evaluating space fundings. This means that undue emphasis should not be placed upon the apparent lack of statistical association between NASA expenditures and nonspace productivity improvements and new product developments. Even apart from measurement difficulties we should recognize that there is a time lag between incubation, technical feasibility, and marketing of technological

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14. J. D. Plunkett, (Denver Research Institute), NASA Contributions To The Technology of Inorganic Coatings, National Aeronautics and Space Administration, Washington, D.C., November 1964, (NASA SP-5014) p. III.

15. Werner Z. Hirsch, "Transformation of New Knowledge for Economic Growth," California Management Review (Berkeley: University of California Press, Spring 1955).

innovations. There is some evidence that the time path through these stages has shortened but it is still well over a decade. (See Table 2) The figures in Table 2 should not be taken as gospel, but the consensus of the Commission cited as the source, is that the pace has increased. But the time involved for the mean elapsed time is a longer period than has elapsed since the inception of the space agency. What it does mean is that the dissemination of the idea and feasible technology are only a part of the innovative process.

Table 2

Average Rate of Development of Selected Technological Innovations 1/

| Factors influencing the rate of technological development | Mean Elapsed Time (years) Incubation Period 2/ | Commercial Development Period 3/ | Total Development |
|---|---|---|---|
| Time Period | | | |
| Early 20th Century (1885-1919) | 30 | 7 | 37 |
| Post-World War I (1920-1944) | 16 | 8 | 24 |
| Post-World War II (1945-1964) | 9 | 5 | 14 |
| Type of Market Application | | | |
| Consumer | 13 | 7 | 20 |
| Industrial | 28 | 6 | 34 |
| Source of Development Funds | | | |
| Private Industry | 24 | 7 | 31 |
| Federal Government | 12 | 7 | 19 |

1. Based on study of 20 major innovations whose commercial development started in the period 1885-1950.
2. Begins with basic discovery and establishment of technical feasibility and ends when commercial development begins.
3. Begins with recognition of commercial potential and the commitment of development funds to reach a reasonably well-defined commercial objective and ends when the innovation is introduced as a commercial product or process.

Source: Report of the National Commission on Technology, Automation and Economic Progress, Technology and The American Economy, Vol. 1 (February, 1966) p. 4.

## II. THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION'S SUBCONTRACTOR REPORTING SYSTEM

The National Aeronautics and Space Administration originated its subcontractor reporting system in August 1962 with voluntary reporting retroactive to January 1962. The expressed purpose was to obtain information for the Administrator on the geographic spread of contract funds as the first-and second-tier subcontractors became involved. With the exception of the Jet Propulsion Laboratory (California Institute of Technology), the covered universe was to include only private business establishments. The system has been in continuous operation since its inception.

The reporting responsibility lies with the firm letting the subcontract. The prime contractor reports to NASA on the first-tier subcontracts and the first-tier subcontractor reports on the second-tier subcontracts. Both value of contract and tasks performed criteria must be met for inclusion in the system. No first-tier subcontracting awards on a prime contract of less than $500,000 are reported; and of those reported, none are for first-tier subcontracts or modifications of less than $10,000. The first-tier subcontractor reports second-tier subcontract awards only when his first-tier award is in excess of $10,000 and his second-tier awards also exceed $10,000. No subcontracting of either tier is reported on those items which do not directly and specifically relate to the execution of a NASA prime contract.

The first-tier subcontract is identified by the prime contract number to which it relates. Although item 7 (see Chart 2) of the instructions requires the contractor initiating the action to enter a

Form Approved
Budget Bureau No. 104-R012.1

For NASA Use Only

SECTION I.

1. PRIME CONTRACT NO.
2. PRIME CONTRACTOR
3. ADDRESS

II. FIRST-TIER SUBCONTRACT

4. SUBCONTRACTOR
5. ADDRESS
6. SMALL BUSINESS ☐ YES ☐ NO
7. SUBCONTRACT NO.
8. SUBCONTRACT AMOUNT $
9. ☐ NEW CONTRACT
10. ☐ MODIFICATION
11. PRINCIPAL PLACE OF PERFORMANCE *(If known)*
12. TYPE OF EFFORT ☐ R&D ☐ NON-R&D
13. DESCRIPTION OF WORK

III. SECOND-TIER SUBCONTRACT

14. SUBCONTRACTOR
ADDRESS
16. SMALL BUSINESS ☐ YES ☐ NO
17. SUBCONTRACT NO.
18. SUBCONTRACT AMOUNT $
19. ☐ NEW CONTRACT
20. ☐ MODIFICATION
21. PRINCIPAL PLACE OF PERFORMANCE *(If known)*
22. TYPE OF EFFORT ☐ R&D ☐ NON-R&D
23. DESCRIPTION OF WORK

24. COMPANY SUBMITTING REPORT
25. SIGNATURE
26. DATE

For NASA Use Only: A. B. C. D. E. F. G. H. I. J.

NASA FORM 667 (REV. JUN 64) PREVIOUS EDITIONS ARE OBSOLETE. REPORT ON NASA SUBCONTRACTS

## INSTRUCTIONS - GENERAL AND SPECIFIC

**A.** This report form is for use by NASA prime contractors and first-tier subcontractors participating in the NASA subcontracting reporting program. Parts I and II of the form are for use by the prime contractors; Parts I, II and III are for use by the first-tier subcontractors.

**B.** NASA prime contractors will complete and submit Parts I and II of the form for each subcontract *(as defined in paragraph E below)* placed by them which is estimated will exceed $10,000 and for each action *(modification)* in excess of $10,000 on such subcontract. Modifications to be reported include actions which result in the decommitment of funds as well as commitments.

**C.** First-tier subcontractors having any subcontracts which are estimated will exceed $10,000 will complete and submit the form in entirety for each subcontract *(as defined in paragraph E below)* placed by them which is estimated will exceed $10,000 and for each action *(modification)* in excess of $10,000 on such subcontract. Modifications to be reported include actions which result in the decommitment of funds as well as commitments.

**D.** For use in reporting on NASA subcontracts, "research and development" means basic and applied research, and design and development of prototypes and processes to *(1)* pursue a planned search for new knowledge, with or without reference to a specific application, *(2)* apply existing knowledge in the creation of new products or processes and, *(3)* apply existing knowledge in the improvement or modification of present products and processes. It excludes subcontracts for the purchase of standard commercial items and services.

**E.** The term "*subcontract*" as used herein means procurement in the excess of $10,000 by the prime contractor or first-tier subcontractor of articles, materials, or services entering into the performance of a specific NASA prime contract. It does not include purchases, regardless of amount, of stock items, materials, or services which cannot be identified with a specific NASA prime contract.

**F.** NASA prime contractors will provide the number of the NASA prime contract to their first-tier subcontractors for entry on the reports.

**G.** The report is to be submitted as soon as possible after placement of the subcontract to the National Aeronautics and Space Administration, Office of Procurement, Code KDG, Washington, D. C. 20546.

**H.** Prime contractors will obtain a supply of the forms from their NASA Contracting Officer. Subcontractors will obtain the forms from the prime contractor.

**Item 1.** Enter the NASA prime contract number.
**Item 2.** Enter name, and division if applicable, of the prime contractor.
**Item 3.** Enter address *(City and State only)* of the prime contractor.
**Item 4.** Enter name, and division, if applicable, of the subcontractor.
**Item 5.** Enter address *(City and State only)* of the subcontractor.
**Item 6.** Check applicable box.
**Item 7.** Enter subcontract or purchase order number specified by the contractor initiating the action.
**Item 8.** Enter in terms of commitments, to the nearest dollar, the amount of the subcontract, or amount of modification to the subcontract. Modifications resulting in decommitments are to be enclosed in parentheses.
**Item 9.** Enter a check if this report is the first report submitted on the subcontract.
**Item 10.** Enter a check if this report is for a modification of a previously reported subcontract.
**Item 11.** Enter the location *(City and State only)* of the principal plant or place of business, where the items will be produced or supplied from stock or where the work will be performed, if known. For construction subcontracts, enter the site of construction.
**Item 12.** Check applicable box to indicate whether effort involves research and development. *(See Item D.)*
**Item 13.** Enter a brief description of the item to be furnished or the work to be performed under the subcontract. *(For example: Environmental control system for Apollo Spacecraft, Fuel Pumps, etc.)*
**Items 14 thru 23.** See Items 4 thru 13.
**Item 24.** Enter the name of the company submitting the report. This should be the name of the prime contractor for reports on first-tier subcontracts; it should be the name of the first-tier subcontractor for reports on second-tier subcontracts.
**Item 25.** To be signed by the company individual submitting the report.
**Item 26.** Enter the date of signature.

GPO 879-842

Chart 2

subcontract purchase number, this requirement has been largely ignored. Consequently, it is not possible to trace the network flow from prime to first- to second-tier subcontractor. Since both subcontracting levels are related only to the prime contract number, this important downward link has been lost.

The schedule also provides for a distinction between research and development (R & D) awards and other types at each subcontractor level. Such information has not been tabulated, and, given the general nature of the technology involved in the space program, it is doubtful whether the information would be useful or credible. To begin with, it is difficult to interpret a definition of R & D as indicated by National Science Foundation experience. Without careful control by NASA, it would be difficult for a reporting unit to properly code its task. Furthermore, the nature of subcontracting on components and services is that they may enter into a R & D process without requiring R & D. The component itself may literally be close to "off-the-shelf" but since the program using it is classified as a R & D one, it is properly part of such a process. For example, if the task were performed in-house, rather than subcontracted, it would certainly be classified as R & D. Such distinctions as the one above should be invariant to institutional arrangements.

## Coverage

The number of prime contractors reporting under the postal-card system has varied as the mandatory reporting has been extended to all primes meeting the cut-off requirements listed above. This mandatory reporting data was 1 January 1964. The consequence of a varying universe over time is to introduce discontinuities into time comparisons of subcontract awards and their characteristics. The NASA tabulations carry data for 12 primes from January 1962 through June 1964; for the first six months FY 65 coverage was expended to 64 prime contractors and for the first nine months of that fiscal year to 74 primes. (Whenever strict compatibility was required for this study, the data for the original 12 primes was broken out separately for the first half of FY 1965. For the six month expended universe period, the data for the 12 account for approximately 84 percent of the value of subcontract awards by the total universe of 64 prime contractors.)

The data for FY 65 also include among the primes several universities (other than California Institute of Technology which is included in the original 12 primes). There are Harvard, Massachusetts Institute of Technology, and the University of Wisconsin. Subcontracts let by the first and last are small in total value. However, MIT, which has been a major recipient of NASA grants for a number of years, subcontracts all of its prime award money, running in the neighborhood of $1 million annually. All university subcontracts covered are awards to business firms primarily classified as aerospace industries.

The Jet Propulsion Laboratory (California Institute of Technology) has always been an anomaly in statistics on the "aerospace industry." Federal industrial statistics are usually based on ownership, and JPL, a university-based creation of NASA, would be classified as a not-for-profit educational institution. The fact that its tasks and products are similar to those carried out in the private for-profit sector of the economy has no bearing on its exclusion. Because of its university affiliation and its nonintegrated mode of operation, JPL tends to purchase goods and services, i.e., lets subcontracts, that are performed in-house in for-profit establishments performing similar operations. Consequently, its subcontracts and their pattern differ from other primes. The same can be said about the operations of other educational and not-for-profit organizations.

As a side note, this question of ownership raises perplexing questions now being reevaluated by Federal agencies concerned with measurement and data collection on advanced technological production processes. For example, to exclude a JPL and an Aerospace Corporation from a census of manufactures distorts the profile of an aerospace industry as described therein. Such organizations are counterparts of private industrial activity and, save for a conventional and arbitrary ownership criterion, are part of a processing industry. Such institutions need to be integrated with others to round out the overall picture of science and technology.

Interpretation of Value Figures and Time

A number of concepts relating to production time must be kept clearly in mind when utilizing the subcontract data. In the first place, "awards" as used by NASA is synonomous with obligations and not with expenditures, receipts, or billings. Where subcontracts are awarded for large subsystems, the magnitude of the dollar values indicate a time span for completion certainly longer than the quarterly reporting period or even a calendar year. However, for relatively small subcontracts such as those awarded by North American Aviation to small California firms, "billing" and "awards" may coincide or, at least, give reasonable assurance that the subcontract is completed within a 12 month period. This timing is due to the nature of the task performed or to the closeness to an off-the-shelf item already in production. It has nothing to do with measurement concepts.

Secondly, both prime contract awards and the subcontracts originating under them, particularly the high value ones, do run for a number of years. Two types of time lags occur as a result of tabulating only awards value. First, the lag between award and work done means that the impact of an award on income and employment in an area is largely related to the time phasing of expenditures aside from the anticipatory influences prior to the actual award. Secondly, the award date and value of a subcontract may bear little relationship to the prime contract award during the given fiscal year. As an example, when we attempted to merge some prime and subcontractor award data, it was found that one prime contractor had committed more than his total prime contract award for the fiscal year to one subcontractor, the inference being that the subcontract was for the amount needed for the life of the program rather than for the particular fiscal year.

In summary, an idealized model here would be of a PERT network formulation where time-phased tasks are identified by the specific tier of contractor, by geographic location, and by value of work done. (Such a network can also be expressed in conventional time-phased input-output matrices with geographic subscripts for each cell.) With such a formulation, the closed flows of work from prime to first-tier and from prime to first- to second-tier subcontractor could be traced with their feedbacks and interactions on each other and on the various regions. This idealized network cannot be developed on the basis of the current NASA prime and subcontractor reporting systems. The flows cannot be traced through, nor can the actual value of work done, at a specified time, be identified in a meaningful way. To go beyond the NASA information system, it is not possible to relate much of this system output to the data within the Federal statistical system.

Another valuation problem we have in the use of the subcontractor data, as well as placing it in relation to prime contract information arises from the changing values of contract awards due, primarily, to changes in scope of work. In the case of prime awards there is always the total estimated cost of the company program for the amount and type of work specified at the time the prime contract is awarded. The award is assigned a specific prime contract identification code applicable only to the company and the specific contract it is awarded. In addition there is an annual award which is based on the estimated work to be performed during any fiscal year. In examining the machine tabulations furnished to UCLA by NASA, it was noted that the estimated cost of the program may change from year to year. This means, of course, that the prime contract has been modified either by the inclusion of new items or the deletion of old ones. That is,there are changes in the scope of work. Such changes are inevitable in the programs run by NASA. The critical question for the analysis of economic impacts and the subcontracting universe is: When does a change in scope of work mean a new contract and a new series in the information system? A contract may be terminated and a new one written, with the same contractor or a different one, but our discussions with NASA personnel indicated that these were administrative rather than policy decisions. There is, however, a tendency to continue modifications of existing contracts and avoid negotiations of new ones because of time and information costs.

For the subcontractor reporting system there is an analogous problem. The reporting form spells out that all modifications in subcontracts in excess of $10,000 have to be reported including "actions which result in decommitment of funds." In the machine tabulations, decommitments are entered as negative amounts. To use such net figures for any specific year introduces biases into the estimates. Consequently, for the UCLA tabulations of subcontractor flows, the following procedure was adopted: Where a positive amount from the same prime to the same subcontractor with the same work description for the same fiscal year as the negative amount could be found, the positive was added and the negative subtracted—leaving, in effect, zero. Where it was not possible to match positive and negative awards for any of the fiscal years, as reported, the negative amount was treated as zero. Where it was feasible to match positive and negative values in different fiscal years the positive was subtracted for the specific year and the negative treated as zero, an arbitrary but workable compromise procedure given the available data.

Dollar Cut-Off Effects

The effect of the dollar cut-off points for both prime and subcontractors in terms of total dollar value coverage is probably in "the noise level." The numbers of contractors—of both types—is likely to be large. NASA makes hundreds of direct contracts of less than $500,000; presumably there are relatively few subcontracts under these small primes. On the other hand, there are probably many unreported subcontracts of less than $10,000. These are more likely to be for housekeeping and maintenance services than for technical tasks. The fact is that little is empirically known about the numbers, value, and geographic location of the "leakages." The conjecture at NASA is that, for the business universe, the subcontractor leakage is about 5 percent of the total. The UCLA staff investigated this leakage with personnel at the Jet Propulsion Laboratory. (JPL may not be representative of the total universe because of its university affiliation.) The leakage estimated for JPL in FY 1964 was approximately $26 million or 15 percent of the value of its subcontracts for that year. Additional investigation turned up another "leakage of $6 million constituting nonreported modifications of original subcontracts, despite the fact that the instructions for subcontractor reporting calls for such information.

The "leakage" factor is probably small and may not warrant emphasis. The critical factor is that so little is known about it.

Place of Performance and Industrial Classification

The accuracy with which the respondent fills in the subcontractor postal card form entry on place of performance is critical for looking at geographic distributions and their resource impacts. The reason for bracketing the discussion of location and industrial classification together is to allow a report on the results of an experiment which matched a sample of NASA subcontractor files with those of the Industry Division, U.S. Bureau of the Census, and with those of the Social Security Board, U.S. Department of Health, Education, and Welfare. The results raised some questions on the quality of place of performance reporting.

One minor point on the method of tabulating place of performance is that the reporting and tabulating system were established for the postal card system to include, as part of any contracting or subcontracting firm, any of its divisions, but to exclude, as independent firms, any of its subsidiaries. Regardless of any economic or administrative significance of such distinctions, analysis of the subcontractor data **indicates** that divisions have sometimes been coded as independent companies due to lack of information.

Another point is the way in which the machine runs are made. The computer program holds the entry for place-of-performance for a particular contract—prime or subcontract—once it is recorded, even though later schedules may indicate a different geographic location. This anomaly is particularly likely to occur when all or part of a prime contract is assigned by a parent company to one of its divisions; such an assignment is not reported as a subcontract, nor is its new place-of-performance indicated on the tabulations.

Such programming rigidity is most likely to affect the larger multi-establishment firms and hence, the larger dollar awards. The programming rigidity is likely to bias the place-of-performance data in a relatively minor way, provided that the proper entries were made in the first place. There is some question on the original accuracy.

Prior to elaborating on the quality of place-of-performance, let us digress to discuss some concepts in industrial classification and measurement since their application may also bias the place-of-performance tabulations.

Economic Impact Analysis and Industrial Classification

Customarily, when the economic-impact problem is raised, it relates to the economic effects of changes in both the level of total expenditures and the composition or "product-mix" of expenditures. Two major types of measurement problems can be specified: (1) the effects of changes in the level of total space spending on aggregate demand and (2) the structural characteristics of such outlays. The aggregative problem, measurement of the effects on total demand, can be approached in terms of aggregative measures of national production, income, employment, and other economic magnitudes (e.g., index of industrial production) and thus present few classification problems. Identification of the structural characteristics of space expenditures impact, however, involves a wide range of classification problems.

The space agency is more likely to be interested in, and concerned about, the structural-impact analysis. Such analysis involves the identification of shifts in resource use (plus or minus) that follow changes in expenditures. The resources of concern include manpower and specific occupational skills; aggregations of personnel representing specialized management capabilities; special-purpose capital equipment; and in some instances, housing, education, and health facilities. Attempts to assess potential resource implications may begin with measurements of products, plants, companies, or industries; the analysis may be performed at a local, a regional or a national level. The essential core is the measurement of structure which involves problems of concepts and definitions. It must be emphasized that such definitional issues as industry, product, and place of performance are not merely technical ones but bear on the important question of whether or not the economic phenomena under consideration to be measured are, in fact, measured. Such issues as the proper basis of classification, the level of aggregation, and the question of compatibility with related data systems are fundamental to the validity and usefulness of any analysis done with NASA generated data.

## Industrial Classification of NASA Subcontractors: An Experiment

The subcontractor award data, as currently processed, cannot be integrated with the economic data collected either by other Federal agencies or by state agencies in cooperative Federal-state statistical programs. For example, it is now impossible to relate prime or subcontract awards to total activity of the industries concerned, or to the detailed industrial activity of local areas. Nor is it possible to systematically trace through the impacts on industries not covered by NASA information systems in industrial detail. An effort was made by the UCLA staff to make the NASA subcontractor data compatible with statistics on production and employment published by other Federal agencies.

The Federal Government collects information for structural resource impact studies through three types of classifications, the firm or enterprise, the establishment or "technical unit," and the product or product class. All three have their appropriate use in analyzing structural impact problems and each type of classification brings with it certain strengths and weaknesses. Since the establishment is more widely used as the basic unit of count in Federal industrial statistics, the UCLA experiment used this classification.

The first step in this attempt to integrate information was to classify the NASA covered establishments as industries compatible with the definitions promulgated for all Federal agencies by the Bureau of the Budget through its Standard Industrial Classification (SIC). In the SIC the establishments are grouped by industry code on the basis of their "major activity," which is defined according to different criteria, dependent on the industries involved. The predominant basis of classification is similarity of products; a second basis is similarity of manufacturing or other processes used; and a third is similarity of inputs, especially material inputs.

An "establishment" is an economic unit (a mine, a factory) which produces goods and/or services. In most instances, the establishment is at a single physical location; it is engaged in only one, or predominantly one, type of economic activity for which an industry code is applicable. Where a single physical location encompasses two or more distinct and separate activities for which different industrial classification codes are applicable, such activities are treated as separate establishments and classified in separate industries provided certain rules can be met. An establishment is not necessarily identical with enterprise or firm, which may consist of one or more establishments, i.e., multi-establishment firm. The enterprise is also likely to produce a wider spectrum of products which cover different industries such as, for example, a General Electric producing household appliances and jet engines for aircraft. The establishment consequently is a more homogeneous production unit.

Using the establishment as the basic statistical unit, each establishment is classified in the industry where its (the establishment's) principal commodities are, by definition, primary (see above discussion of activity on the basis of value). However, the establishment can, and often does, produce commodities that fall outside the scope of the industry where it is classified. Such products are designated as secondary products of the specified sector since they are primary for another. It must be noted, however, that primary and secondary product designations are strictly a function of the classification system used; the more aggregative the system for classification, the fewer the secondary products.

Another basis for classification, already mentioned above, is the product, without regard to the establishment (or enterprise) in which it is produced. As the establishment classification is developed in the SIC, the establishment and the product classification are closely interrelated. The Bureau of the Census, in its Census of Manufactures, extends the most detailed Standard Industry Classification; this is the four digit coded industrial sector in which each product class is primary. Beyond the first four digits the Bureau of the Census defines a five digit product class plus unique sixth and seventh digits. Consequently, a seven digit product code carries within its numbering structure the product class, industry, group and major group. That is, the coding system permits us to move from the most detailed product class to the most aggregative industrial classification, which is the major industry division (2 digit level) such as manufacturing, construction, etc. The 1963 Census of Manufactures include approximately 7500 seven digit product codes, 1130 five digit product classes, and 425 four digit industries.

The Bureau of the Budget, in 1963, established the Standard Enterprise Classification, a reconciliation of four different SIC-related company classifications then in use by government agencies (Bureau of the Census, Federal Trade Commission, Internal Revenue Service, and Securities and Exchange Commission). The new classification system covers all economic activities and provides for company classification at two, three, and four digit levels of detail, with each four digit category defined in terms of SIC establishment codes.

Industrial Classification of NASA Subcontractors

The widespread use of the establishment classification system in the Federal statistical system is a cogent argument in favor of its use for studying the impact of NASA expenditures. It is used by the Bureau of the Census in its periodic censuses, by the Bureau of Labor Statistics in its continual series on employment, wages, hours of work, labor productivity, etc. Integration of NASA data on an establishment basis consequently offers a wider framework for analysis. It is for this reason the initial attempt was on an establishment basis.

Since the Bureau of the Census is the most important nondefense agency collecting economic, social, and demographic information, the UCLA staff decided to use its industrial coding structure. The process here involves a matching of NASA subcontractor place of performance lists with the Census master name, location, and industry codes. However, because of the proprietary nature of certain Bureau of the Census information, it was necessary for NASA to request the information and to supply what was needed for the matching. This was done by NASA and cooperation between the Federal agencies was excellent.

The request, as initiated by UCLA through NASA was confined to the Census of Manufactures master list. An examination of NASA subcontractor tabulations indicated that the major subcontracts were in manufacturing. NASA furnished the Census Bureau a listing of 98 names drawn in sequence (not a random sample) from the middle of the NASA unduplicated listing of all subcontractors, about 4200 names at this time. The Census Bureau then matched this list with their own. The results were as follows:

18 names -- a complete identification

10 names -- identified as manufacturing enterprises but with no reported establishment in the city reported to NASA as place of performance

70 names -- identified as nonmanufacturing establishments

The Census attempt raised several critical questions about both the NASA subcontractor reporting system and the worthwhileness of proceeding with all 4200 names. First is the lack of locational matching for the 10 manufacturing firms. These might be consultive type operations, but it also indicates that NASA may be picking up sales offices in their reporting system rather than the actual place of performance. If so, the geographic distributions are biased. Secondly, NASA may be picking up some subcontractors that, by definition, should be excluded from the reporting system.

At the suggestion of the Census Bureau staff, another attempt was made for industrial classification, this time having the Social Security Board attempt to match the NASA subcontractors with its enterprise list of covered firms. Because of the inclusion of nonmanufacturing activities and the enterprise unit in this list, the attempt was more successful. These results were as follows for 69 companies covered:

55 -- complete identification of company

7 -- no identification in city listed by NASA

2 -- no identification because of differences in names between lists

1 -- wrong state for NASA place of performance

4 -- nothing in SSB list.

The experiments on matchings for industrial coding are, in a small measure, a cursory evaluation of the quality of reporting on certain schedule items. The Census matching was limited to manufacturing establishments, the SSB to company across SSB covered industries. The establishment versus enterpise base is identical for single establishment enterprises, and it is likely that many nonmanufacturing firms, such as consulting engineers and computer services, are of this single unit basis. The lack of geographic identification between NASA reporting and the other lists is most serious for analyses of geographic impact. Here there is a question of detail; for example, state totals may be more accurate than those for cities. On the basis of these matchings, UCLA and NASA decided to defer further industrial codings. This decision meant that UCLA could not carry out its original plan to perform a network analysis of the point-of-origin to point-of-destination with an industry-to-industry flow overlay.

This experiment did not invalidate the use of the subcontractor data for more aggregative types of analyses. The next section of this report describes such efforts.

## III. APPLICATIONS OF THE SUBCONTRACTOR REPORTING SYSTEM

The principal problems in the collection and use of economic data are succinctly summarized by Stone as those of economic design and those of statistical design.[1] The problem of economic design deals with what we want to know and how we go about amassing the facts. The problem of statistical design deals with ways of ascertaining and restricting errors of observation. The user of economic data would like to control his data within a framework based upon the above designs. Unfortunately, the realities are often such that the data control the analysis. Unless the user is involved in the collection process, which usually means either a close working arrangement with a public agency or with being a member of its staff, he must work with data often collected for other purposes. Users then must work with what is available with less reliance on data specifically shaped to their purpose. In fact, there may well be an interplay between the model formulated or the hypotheses to be tested, as the brute facts of data availability impinge upon the theoretical statement of the problem.

These points should not be unduly labored. They bear, however, on two problems in formulating models or testing hypotheses; due consideration should be given both to formulations that can make use of imperfect information and to the strong ties that exist between formulation and empirical implementation (between the user and the

1. Richard Stone, The Role of Measurement in Economics (Cambridge, England: Cambridge University Press, 1951) pp. 10-12.

constructor of data). To some degree the division is between universities and the Government, each with its own aims and opinions about the measurement of economic phenomenon. Unfortunately, there are many difficulties in communication between the two.

The applications of NASA generated data presented in this and the following section were designed to serve two purposes: first, for NASA's major interest, to aid in evaluating some NASA generated data, principally the subcontractor data collection "postal card system"; and, second, for UCLA's main interest, to investigate specific questions concerning the nature and relationship between prime and subcontractors, and the geographic ramifications of these relationships. In Section IV, an effort is made to explain the regional pattern of work performed through statistical measures of association between NASA generated activity and selected economic variables. In all cases the investigations were formulated with due regard to our judgment on the quality of the available data.

Summary

In investigations of this nature it is customary to proceed through hypothesis formulation and hypothesis testing. Although it verges on the edge of presumptuousness, this ritual will be followed, although what was done may be considered as being closer to hypothesis generating than testing. The more important conclusions are as follows: There is indicative evidence

1. That the overflow producer as a subcontractor is much less important than he was historically in the aircraft/aerospace industry.

2. That there is a relatively closed network of firms performing on space agency programs. This hypothesis is supported by evidence of considerable overlap in terms of value between firms performing both as prime contractors and as subcontractors. However, some firms function primarily as prime contractors; others, as subcontractors.
3. That, in terms of value of awards, it does not necessarily follow that there is a generic difference between prime contractor tasks and subcontractor tasks. On the basis of available evidence, it is hardly possible to speak of a hierarchy of tasks based on the hierarchy of prime contractors and first-tier subcontractors.
4. That the relative amount of interbusiness transactions remains relatively stable. Despite sharp changes for several of the top prime contractors, the ratio of subcontract awards to prime awards remained constant. There is indirect support for this hypothesis from the weapons system field.
5. That for the individual firms the relative amounts of first-tier subcontracts differ in their state distributions over time. Although this is borne out by the data, the aggregate subcontracts show considerably less variation in geographic distribution. This is due in part to the tendency for one prime to replace another prime with the same subcontractor.
6. That the distribution of net work is more widely spread over the states and less concentrated in certain areas than prime contract awards alone. Not only is this true, but

the inclusion of subcontract awards alters the ranking of states receiving contract awards. No matter which measure is used, prime contracts or net work, California dominates in value.

7. That distance between states does not appear to be an important variable in the regional flows from prime to first-tier subcontractor; however, proximity (intraregion distance) is an important variable. Generally, of the total first-tier subcontracts awarded in a region, a greater percentage of them originate inside the region (intraregional) than outside it. These facts are also evidence that there is a geographic network of regional technological competence; the "distance paradox" here, is analogous to the observations concerning cross-hauling between regions in other industrial activities. That is, that apparently comparable goods are both imported into, and exported from, a region.

## The Subcontractor Data Universe

The subcontractor reporting system, described in Section II, is summarized in Table 3. The number of reporting primes in fiscal year 1965 had expanded over sevenfold from the original 12 primes covered through fiscal year 1963. This expansion meant a changing universe subsequent to June, 1964, with the result of establishing different time periods for analysis. In an effort to deal with a consistent set of data, the UCLA effort is generally restricted to the analysis of the original 12 prime contractors covered for the

Table 3

Comparison of NASA's Reported Subcontracts With Prime Contracts [1]
Fiscal Years 1960-1965

(dollar estimates in hundreds of thousands)

| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 |
|---|---|---|---|---|---|---|
| Prime contracts[1]: Annual | 229 | 534 | 1229 | 2534 | 3889 | 4553 |
| Cumulative | 229 | 763 | 1992 | 4586 | 8475 | 13029 |
| Subcontracting reporting system | | | | | | |
| Number of reporting primes | -- | 12[2] | 12 | 12 | 12-45[3] | 64-86[3] |
| Value of primes covered: Annual | NA | 290 | 706 | 1601 | 3302 | 3780 |
| Cumulative | NA | 290 | 996 | 2597 | 5899 | 9680 |
| Percentage of total primes[1]: Annual | NA | 54.4 | 57.4 | 61.7 | 84.9 | 83.0 |
| Cumulative | NA | 38.0 | 50.0 | 56.6 | 69.6 | 74.3 |
| Net first- and second-tier subcontracts reported value: Annual | NA | NA | NA | NA | 849 | 1075 |
| Cumulative | NA | NA | NA | 682[4] | 1531 | 2606 |
| As a prt. of primes covered: Annual | NA | NA | NA | NA | 25.7 | 28.4 |
| Cumulative | NA | NA | NA | 263[4] | 26.0 | 26.9 |

1. Prime contracts exclusive of those to other government agencies or those outside the U. S.

2. January - June 1962.

3. First number indicates number of reporting primes at beginning of fiscal year, second number reporting at end of fiscal year.

4. Total for 18 months, January 1, 1962 - June 30, 1963.

Source: "NASA Subcontracts Fiscal Year 1965" - draft of semi-annual report to NASA by Economic Associates, Inc., Washington, D.C., February 1966.

period January, 1962, through June, 1964.[2] The original 12 primes accounted for approximately 64 percent of prime contract awards to business (including Jet Propulsion Laboratory) in both fiscal years 1963 and 1964.

Through fiscal year 1965, $2.6 billion of subcontract awards were reported through the postal card system.[3] As would be expected with an expanding universe of prime contractors covered, the percentage of total value of prime awards in the system has increased from approximately 57 percent in fiscal 1963 to 83 percent in fiscal 1965. In all, about three-quarters of the cumulative value of NASA prime contract awards (exclusive of those awarded to other government agencies and to foreign suppliers) are covered. It is not the value of primes covered as much as the time-phasing of adding new prime contractors into the system that raises analytical difficulties.

The Nature of Subcontracting

Peck and Scherer in their definitive work on the weapons acquisition process developed a classification of weapons systems firms by their various economic roles.[4] The types distinguished can also

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2. The original 12 prime contractors are: Aeroject General Corp.; Boeing Co.; Chrysler Corp.; Douglas Aircraft Co., Inc.; Grumman Aircraft Engineering Corp.; Ling-Temco, Vought Inc.; Lockheed Aircraft Corp.; McDonnell Aircraft Corp.; North American Aviation, Inc.; Space Technology Labs., Inc.; (TRW); United Aircraft Corp.; California Institute of Technology.

3. Cancellations of both first- and second-tier subcontracts are treated as negative amounts in the quarter recorded.

4. Morton J. Peck and Frederic M. Scherer, "The Weapons Acquisition Process: An Economic Analysis"(Boston, Mass.: Division of Research, Graduate School of Business Administration, Harvard University, 1962) pp. 114-116.

represent the "space systems" firms, and, following their categories, we can specify the following general types:

1. The space systems firms: Such firms contract to deliver a fairly complete system, as for example, a launch vehicle. They undertake a great deal of development work and are responsible for delivery of the complete system. These are prime contractor firms.

2. The subsystem firms: These firms provide major subsystems, such as the guidance system, that make up the complete space system. Depending upon the organizational pattern, such firms may or may not be subcontractors.

3. The overflow producers: Such producers receive parts of the project from the space system firms, usually on subcontract. They differ from the subsystem firms in that their assignments tend to be within the areas of competence of the space systems firms. The rationale for such subcontracting in a space program is usually the lack of capacity in the firm initiating the contract.

4. The parts firms: Such firms supply components such as tubes, gauges, valves, instruments, and so forth.

5. The materials makers: These firms supply basic materials such as aluminum, high quality steels, ceramics and chemicals (such as propellants of various types).

Any classification is arbitrary and brittle and tends to break down if pushed too far. In discussing systems and subsystems one can go on to major subsystems, minor subsystems, elements, components, and so forth. For example, computers are elements of the guidance subsystem of a launch vehicle, and yet, computers themselves can be viewed as subsystems. The minor subsystems shade off to the elements (also called components and parts) which are often developed by second-tier subcontractors. Obviously, any dividing line between categories is imprecise.

For the prime contractor—the space or major systems firm—the purpose of subcontracting is to obtain the division that results in the least cost operation between in-house and nonintegrated activities. Given this objective, the firm must act on make or buy decisions within NASA procurement policies. The NASA contracting office can challenge the inclusion of an item in a contract if:

a. it is not regularly produced by the contractor and is unavailable from other firms at comparable prices;

b. it is not regularly manufactured by the contractor and is available from other firms at lower prices.

Conflicts may well arise as prime contractors weigh the advantages or disadvantages of attempting to diversify or limit themselves to present skills and products; hedge against uncertainties of programmatic changes; struggle with management problems involved with subcontracting, and so forth. Such management considerations and NASA policies set the framework for the volume of interbusiness transactions and prime-subcontractor relationships.

Subcontracting in the aircraft industry has historically been characterized by work assignments to the overflow producer. The rationale for this was the feast or famine character of contracts, the desire to hedge against uncertainties, the wish to avoid the specific impact of cutbacks in particular programs, and so forth. How important is the overflow firm in relation to the subsystem firm in the space program? On the basis of our current work we cannot provide a definitive answer. Our own judgment, based on an examination of the subcontractor tasks reported and the organization of the industry, is that the subsystems firm is more important in value of subcontracts awarded (see discussion below on hierarchy of tasks and firms). As a matter of fact, Peck and Scherer note that since 1959 the dominant form of subcontracting for weapons systems has been towards various types of subsystems, to subsystems firms, and away from the traditional form of overflow producers.[5]

Commonality Between Prime and Subcontractor Universes

At the outset of this study, one hypothesis formulated for testing was that a relatively closed network of establishments performed space agency work and was linked together through specialized technological capability. Because of data limitations, this hypothesis was not tested. What has emerged from the analysis is evidence that a considerable commonality exists between prime contractor and subcontractor firms; this may be indirect evidence for the validity of the establishment hypothesis for the period covered.

In preceding discussions a distinction was made between prime contractor and subcontractor firms. There is no such sharp

5. M. J. Peck and F. M. Scherer, op. cit., pp. 148-149.

distinction in the period covered. As demonstrated in Table 4, firms tend to be both a prime and a subcontractor with the resultant relationship being analogous to taking in each other's wash. For both fiscal years 1963 and 1964, taking only the 12 top primes, approximately 68 percent of the value of their first-tier subcontracts were awarded to firms listed in the top ranking 100 NASA primes.[6] In turn, the top 100 primes were awarded approximately 90 percent of the value of prime awards in each year. The subcontracting figure includes transfers between establishments of multi-establishment firms, where reported. It would also include subcontracting to subsidiary firms of the primes, but we were not able to adequately trace such flows.

Despite the tendency for firms to be both primes and subs, a certain degree of specialization does occur in the sense that some of the 100 top prime contractors functioned primarily as primes while others functioned primarily as subcontractors. Of the first 15 prime contractor firms in order of <u>subcontract awards</u> for fiscal 1964, nine are primarily subcontractors and only secondarily prime contractors. Among this group are such firms as Hughes Aircraft, Westinghouse, and Garrett Corp. North American Aviation, although receiving about 26 percent of the value of prime contracts awarded to the top 100 primes, received approximately 5 percent of the

6. The netting out of second-tier subcontracts had little effect on the subcontracting percentages. This deduction in all probability would be swamped if the entire 100 primes were covered for subcontract awards.

Table 4

Top 100 NASA Primes: Relative Prime and Subcontract Awards From Top 12 Primes, 1963 and 1964[1]

| Fiscal Year | Percent of Subcontracts[2] | Percent of Prime Contracts | Number of Primes |
|---|---|---|---|
| 1963 | 68 | 90 | 61 |
| 1964 | 69 | 91 | 67 |

1. Includes Jet Propulsion Laboratory.

2. Includes subcontract awards between 12 prime contractors and intra-firms subcontracts where reported.

Source: National Aeronautics and Space Administration Procurement Reports and NASA computer tabulations of subcontracts by place of performance. (Some adjustments and corrections were made to published data.)

subcontract awards or slightly more than 4 percent of its prime awards.[7]

The fact that there are firms which act primarily as subcontractors does not necessarily mean a generic difference between prime contractor tasks and subcontractor tasks. Since the prime contractors differ in their subcontracting patterns (for example, some subcontract for component parts; others, for subsystems), the subcontractors differ from each other. The JPL subcontract for Surveyor, awarded to Hughes, bears more resemblance to work performed by many primes than for the component parts subcontracts awarded by North American. On the basis of available information, it is hardly possible to speak of a hierarchy of tasks based on the hierarchy of first-tier subcontractors and prime contractors. Below the first-tier subcontract there might be such a hierarchy, since the deeper in the structure of production the more the subcontract is for "off-the-shelf" components.

The "hierarchy" of tasks and subcontracting practices by the large primes shows up in the relative importance of their mutual interactions. Table 5 is a tabulation of the relative allocation of the top 20 primes' (1964) subcontracts for the first half of fiscal 1965 to the top 100 primes (1964) including their own establishments. The range varies considerably, and North American Aviation, with approximately 40 percent of both total awards and awards to the top 100, dominates the average award of 59 percent.

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7. The interchange between primes in part explains our difficulty in the industrial coding of the subcontractors described. Basically, the group covered are manufacturing firms. They account for a large part of the value of subcontract awards but are a relatively small part of the <u>number</u> of subcontractors. The omitted group, large in number, are nonmanufacturing firms in construction and the service activities.

Table 5

Percent of Subcontract Awards By Top 20 Primes
To Top 100 Primes, July - December, 1964 1/

| Prime Contractor | Total Subcontract Awards (in millions | Subcontract Awards To Top 100 Primes of dollars) | Percent |
|---|---|---|---|
| North American Aviation | 191.1 | 111.8 | 58 |
| McDonnell Aircraft | 41.6 | 34.6 | 83 |
| Douglas Aircraft | 30.8 | 25.4 | 82 |
| Boeing Aircraft | 16.0 | 6.4 | 40 |
| Grumman Aircraft | 48.4 | 18.7 | 38 |
| General Dynamics | 3.6 | 1.1 | 31 |
| General Electric | 7.1 | 4.1 | 54 |
| Aerojet General | 19.1 | 5.0 | 26 |
| I B M | 0.8 | 0.4 | 46 |
| Chrysler Corp. | 24.6 | 17.2 | 70 |
| R C A | 8.0 | 4.1 | 51 |
| Bendix | 1.9 | 0.5 | 26 |
| General Motors | 0.9 | 0.1 | 11 |
| Lockheed Aircraft | 6.1 | 3.1 | 52 |
| United Aircraft | 1.9 | 0.1 | 6 |
| Raytheon | 1.2 | 0.7 | 60 |
| Philco Corp. | 1.8 | 1.3 | 72 |
| Ling-Temco-Vought | 0.4 | 2/ | 8 |
| Jet Propulsion Laboratory | 45.7 | 31.6 | 69 |
| Total | 451.7 | 265.9 | 59 |

1. JPL was added to the 100 primes. TRW and Brown Engineering reported no subcontracts in this period.
2. Less than $50,000.

Source: National Aeronautics and Space Administration computer tabulations of subcontract awards by place of performance.

The conclusion that there is a large overlap between prime contractor firms and subcontractor firms has implications not only for such issues as the nature of subcontracting tasks and capabilities and favorable treatment for labor surplus areas and small business, but also for the more general question of regional impact.

Interbusiness Transfers

For the three year period covered, the annual percentage of net subcontract awards to prime contract awards remained relatively stable (see Table 3). This stability is surprising because there were many reasons to expect instability, such as differences in programs and stages of program development; differences in in-house capabilities of the individual firms; and differences in the time lags between awards and work performed. In addition, there are purely data collection reasons, such as variations in the number of primes covered and the various value cut-off provisions used. The data presented in Table 6 show that, at least for the 12 original prime contractors, there were some sharp changes in the subcontracts to prime ratio—defined in the same way—between fiscal 1963 and fiscal 1964. However, the average for the 12 remained virtually unchanged due in large part to North American, the dominant firm. Fluctuations in the individual ratios virtually cancelled each other out.

One might summarily dismiss the relative stability of the subcontracts to prime contracts award data for reasons of time coverage, the concept of awards rather than work performed, etc., as simply an averaging phenomenon. It may well be this, but there is analogous

Table 6

12 Original Prime Contractors—Relationship of Subcontracts Reported To Prime Contracts Awarded In Specified Years[1]

| Prime Contractor | Percent Subcontracts of Prime Awards[2] FY 63 | FY 64 |
|---|---|---|
| Aerojet General Corp. | 34 | 49 |
| Boeing Co. | 7 | 24 |
| Chrysler Corp. | 13 | 4 |
| Douglas Aircraft Co., Inc. | 15 | 15 |
| Grumman Aircraft Engr. Corp. | 42 | 82 |
| Ling-Temco-Vought, Inc. | 9 | 10 |
| Lockheed Aircraft Corp. | 1 | 1 |
| McDonnell Aircraft Corp. | 46 | 53 |
| North American Aviation, Inc. | 34 | 30 |
| Space Technology Labs, Inc. (TRW) | 1 | 5 |
| United Aircraft Corp. | 8 | 9 |
| California Institute of Technology (JPL) | 76 | 78 |
| Average | 32 | 33 |

1. The underlying data differ in minor ways from those in Table 1.
2. Computed from the relationship between the value of subcontracts awarded by the prime during the specified year to the primes awarded to it in that year.

Source: National Aeronautics and Space Administration Procurement Reports and NASA computer tabulations of subcontracts by prime contractor.

evidence from the military weapons field that interbusiness transactions ratios in the aerospace and military electronics industries do have some stability. Peck and Scherer investigated interbusiness transactions in these sectors in the 1956-59 period and their results are presented in Table 7. Their definition of interbusiness transactions and cost of materials is a broader one than the NASA definition of covered subcontracts. Many of the firms included in their study are, in all probability, included in the NASA prime contractor universe. Also, the technology involved may not be too dissimilar from that required for NASA contracts. Their evidence is indicative, but not definitive, insofar as it relates to work performed for NASA.

Some variations in the subcontracting ratios between the different firms are apparently built-in because of institutional factors. For example, Jet Propulsion Laboratory, attached to an educational institution, has limited in-house production and allied service capability. From the description of work tasks for subcontractors, it is apparent that JPL lets subcontracts not only for "hardware" items but also for services that a firm, such as the Chrysler Corporation, is likely to perform in-house. Consequently, the high subcontracting ratio for JPL is not so surprising.

Current capacities and their relationship to make-or-buy decisions were mentioned above. NASA policies here do affect the subcontractor ratios. Somethingof this nature apparently applied to Grumman Aircraft which has the highest subcontracting ratio for fiscal 1964. At that time all of Grumman's space work was performed in a relatively small plant in Bethpage, New York. The approximate doubling of its

Table 7

Subcontracting and Purchase Payments for Various
Types of Weapons Firms: July 1956-June 1959
(in percentages)

| Type of Firm | 1956 July-December | 1957 January-June | 1957 July-December | 1958 January-June | 1958 July-December | 1959 January-June |
|---|---|---|---|---|---|---|
| Large airframe and missiles | 56 | 56 | 60 | 57 | 52 | 56 |
| Medium airframe and missiles | 52 | 51 | 55 | 49 | 48 | 49 |
| Small airframe and missiles | 75 | 76 | 75 | 73 | 76 | 65 |
| Aircraft and missile assembly (and components) | 52 | 50 | 44 | 39 | 45 | 45 |
| Broad electronics - large | 58 | 49 | 51 | 46 | 50 | 50 |
| Broad electronics - medium | 41 | 40 | 35 | 36 | 36 | 38 |
| Military electronics - large | 62 | 65 | 49 | 53 | 43 | 52 |
| Military electronics - medium | 57 | 55 | 58 | 52 | 43 | 47 |
| Aircraft and rocket engines | 64 | 62 | 59 | 57 | 48 | 52 |

Sources: Merton J. Peck and Frederic M. Scherer, The Weapons Acquisition Process: An Economic Analysis (Boston, Mass: Division of Research, Graduate School of Business Administration, Harvard University, 1962), Table 5A.6, pp. 624-625.

subcontracting ratio from fiscal 1962 to 1963 from 42 to 82 percent can, in large part, probably be explained by the fact that its rank position in the ordering of prime contractors by value changed dramatically between these two fiscal years. It went from 10th to 5th place adding over $100 million in prime awards. Given the previous year's tasks, its in-house capacities could provide over half the value of work; with the increase in awards, and no expansion in capacity, Grumman became a system's manager, heavily dependent upon subcontracting to accomplish its program. As another example, McDonnell (based on the description of its subcontracts in the NASA reporting system) subcontracts for complete subsystems unlike North American which buys component parts.

Some Regional Implications

The combination of the individual prime contractor firms' subcontracting ratios (see Table 6) and the interrelationship between primes in subcontract awards (see Table 5) must have a profound influence on the geographic distribution of subcontract awards. This can be inferred by the examination of data in Table 8. Not only are there wide variations in the proportion of first-tier subcontract awards by state, but state distributions by individual firms vary significantly over time.[8]

The data in Table 8 indicate that, with the notable exception of North American, the primes tend to change the geographic locus of their subcontract awards. These changes are not thought to be capricious

8. Tabulating by firm and by state tends to obscure the exact place of performance flows. On the whole, the firm-state tabulation introduces more stability into the figures.

Table 8

12 Original Primes: Partial Relative Allocation of First-Tier Subcontracts, By State FY 1963, 1964 and First Nine Months 1965

(Percent)

| | FY 1963 | FY 1964 | 1 July 1964 31 March 1965 |
|---|---|---|---|
| Aerojet General Corp. | | | |
| California | 33 | 17 | 79 |
| Pennsylvania | 43 | 68 | 1 |
| Boeing Company | | | |
| California | 9 | 33 | 4 |
| New Jersey | 16 | 1 | 31 |
| New York | 1 | 1 | 33 |
| California Inst. of Tech. (JPL) | | | |
| California | 92 | 66 | 75 |
| New Jersey | 1 | 9 | 7 |
| Chrysler Corp. | | | |
| Alabama | 1 | * | 23 |
| California | 11 | 50 | 21 |
| Louisiana | 61 | 19 | 2 |
| Michigan | 10 | 7 | 1 |
| Douglas Aircraft Co., Inc. | | | |
| California | 66 | 33 | 2 |
| Iowa | 1 | 42 | 47 |
| Minnesota | 15 | 2 | 7 |
| Grumman Aircraft Engr. Corp. | | | |
| California | 7 | 29 | 53 |
| New Jersey | 2 | 20 | 1 |
| New York | 50 | 14 | 16 |
| Pennsylvania | 24 | 16 | 1 |

* Less than 0.5 percent.

Table 8—Continued

| | FY 1963 | FY 1964 | 1 July 1964 31 March 1965 |
|---|---|---|---|
| Ling-Temco-Vought | | | |
| California | 3 | 1 | 23 |
| Minnesota | 36 | 2 | 6 |
| New Jersey | -- | 2 | 20 |
| Florida | -- | 93 | 5 |
| Lockheed Aircraft Corp. | | | |
| California | 62 | 28 | 55 |
| New York | 12 | 23 | 1 |
| Massachusetts | -- | 20 | -- |
| McDonnell Aircraft Corp. | | | |
| California | 19 | 50 | 51 |
| Maryland | 11 | 3 | 11 |
| New York | 30 | 2 | 7 |
| North American Aviation, Inc. | | | |
| California | 48 | 47 | 55 |
| Minnesota | 12 | 12 | 9 |
| Space Technology Labs, Inc.(TRW) | | | |
| California | 44 | 62 | 44 |
| Minnesota | 25 | -- | 2 |
| Pennsylvania | -- | 16 | 1 |
| United Aircraft Corp. | | | |
| California | 18 | 6 | 4 |
| Florida | 17 | 14 | 6 |
| Michigan | 2 | 15 | 14 |
| New York | 22 | 24 | 22 |

Source: National Aeronautics and Space Administration computer tabulations of subcontract awards by place of performance.

or accidental but rather are related to the time-phasing of programs and to the particular tasks involved. Moreover, what is true for the individual firm is not true for the aggregate; that is, the wide individual firm fluctuations in geographic placements of subcontracts tend to cancel out. In part, this relative stability is explained by the dominance of North American. But there is another important factor at work, the tendency for one prime to replace another prime with the same subcontractor. Or, to phrase it differently, the primes tend to utilize the same subcontractor for the same task or produce, which is possible either because the various programs are at different phases or because of unutilized capacity.

Many of the large firms listed in the yearly rankings of the top 100 primes, and who also perform as subcontractors, tend to concentrate their space activities in one location. These are multi-establishment firms, and their geographic centralization reflects the need for specialized tooling and/or for specialized skills. These needs as well as management control probably make concentration economically feasible. For example, Lockheed does much of its space work at Sunnyvale, Calif.; Chrysler works out of Huntsville and New Orleans; and Boeing, which also works out of New Orleans. Such major subcontractors as ALCOA and Bendix have built facilities for space activites in Iowa.

## Geographic Spread of Prime Contracts

A major motive for creating the subcontractor reporting system was to ascertain the degree of spreading out, if any, that the subcontractors would introduce into the geographic location of NASA work.

The postal card reporting system is a NASA innovation and represents the only continual Federal effort to go beyond the initial place of performance, that of the prime contractors.

The postal card data does show that the inclusion of first- and second-tier subcontractors tends to spread NASA dollars out over the states and lessen the state concentration of work performed. Chart 3 presents data showing the relation between the state distribution of the value of prime contract awards over $25,000 to business (including JPL) and the prime state distribution of where net work is performed as measured by prime flows adjusted for subcontract moneys. The presentation is in the form of an unsmoothed Lorenz curve with the horizontal axis showing the cumulative percent of prime awards, ranked by state, and the vertical axis, the cumulative percent of net work performed (see Tables 9 and 10). The forty-five degree line through the point of origin represents the hypothetical distribution if the relative allocations of both prime and net work were identical. Since the curve is below the equal distribution line, the inference is that prime contracts are less equally distributed and conversely that net work is more evenly distributed among the states.

In the fiscal year shown in Chart 3, only six states out of 50 (plus the District of Columbia) received no prime contract awards over $25,000 to business. These six were Kansas, Maine, Montana, North Dakota, South Carolina, and South Dakota. In the flow of subcontracts from the 12 covered primes, all six were covered.

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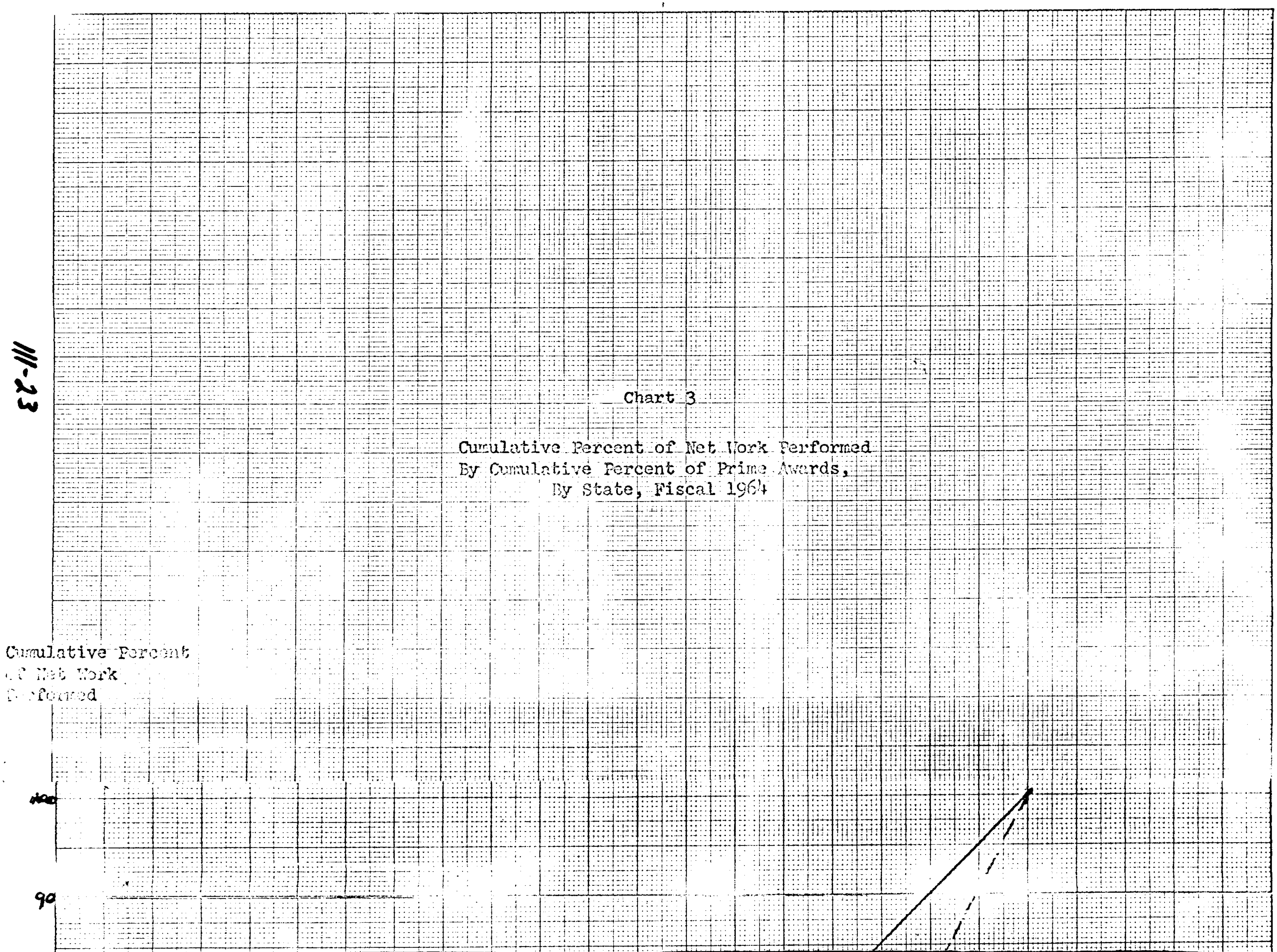
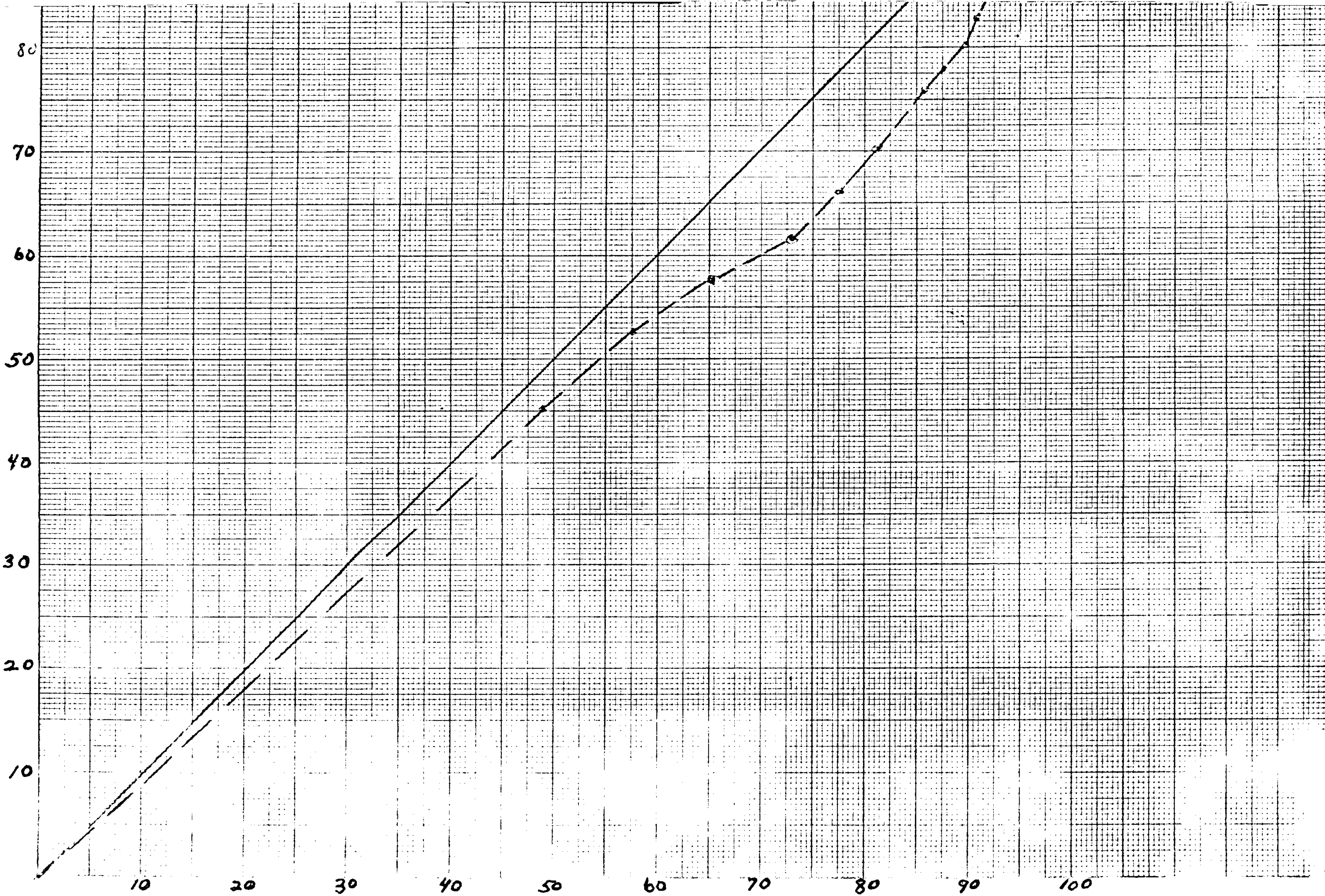
Chart 3

Cumulative Percent of Net Work Performed
By Cumulative Percent of Prime Awards,
By State, Fiscal 1964






Cumulative Percent of Total Value Prime Awards

Source: Table 10

Table 9—Continued

| | Prime Contract Awards To | Rank | 1st - 2nd Tier Subcontracts From | 1st - 2nd Tier Subcontracts To | Net (Columns 1-3+4) | Rank |
|---|---|---|---|---|---|---|
| Illinois | 8.1 | 20 | -- | 11.3 | 19.3 | 20 |
| Michigan | 6.6 | 21 | -- | 7.9 | 14.5 | 21 |
| Arizona | 4.9 | 22 | -- | 4.6 | 9.5 | 24 |
| Georgia | 3.8 | 23 | 0.15 | 0.5 | 4.2 | 26 |
| Indiana | 2.4 | 24 | -- | 9.3 | 11.7 | 23 |
| Tennessee | 1.8 | 25 | -- | 0.8 | 2.6 | 28 |
| New Mexico | 1.6 | 26 | -- | 1.4 | 3.0 | 27 |
| North Carolina | 1.41 | 27 | -- | 1.1 | 2.5 | 29 |
| Oklahoma | 0.96 | 28 | -- | 4.2 | 5.1 | 25 |
| West Virginia | 0.7 | 29 | -- | 0.08 | 0.8 | 35 |
| Oregon | 0.66 | 30 | -- | 0.6 | 1.3 | 31 |
| New Hampshire | 0.5 | 31 | -- | 0.3 | 0.8 | 34 |
| Delaware | 0.42 | 32 | -- | 0.7 | 1.1 | 33 |
| Iowa | 0.4 | 33 | -- | 37.5 | 37.9 | 16 |
| Nevada | 0.38 | 34 | -- | 0.8 | 1.2 | 32 |
| Mississippi | 0.3 | 35 | -- | 0.4 | 0.7 | 36 |
| Rhode Island | 0.29 | 36 | -- | 1.1 | 1.3 | 30 |
| Utah | 0.2 | 37 | -- | 0.2 | 0.4 | 39 |
| Arkansas | 0.15 | 38 | -- | -- | 0.2 | 41 |
| Idaho | 0.14 | 39 | -- | 0.03 | 0.2 | 40 |
| Alaska | 0.03 | 40 | -- | -- | 0.03 | 44 |

Table 9—Continued

| | Prime Contract Awards To | Rank | 1st - 2nd Tier Subcontracts From | 1st - 2nd Tier Subcontracts To | Net (Columns 1-3+4) | Rank |
|---|---|---|---|---|---|---|
| Hawaii | 0.03 | 41 | -- | -- | 0.03 | 45 |
| Kentucky | 0.03 | 41 | -- | 0.06 | 0.09 | 42 |
| Wyoming | 0.03 | 43 | -- | -- | 0.03 | 46 |
| Vermont | 0.02 | 44 | -- | 0.6 | 0.6 | 37 |
| Kansas | -- | 45 | -- | 0.5 | 0.5 | 38 |
| Maine | -- | 45 | -- | 0.04 | 0.04 | 43 |
| Montana | -- | 45 | -- | 0.01 | 0.01 | 48 |
| Nebraska | -- | 45 | -- | -- | -- | 50 |
| North Dakota | -- | 45 | -- | -- | -- | 50 |
| South Carolina | -- | 45 | -- | 0.02 | 0.02 | 47 |
| South Dakota | -- | 45 | -- | 0.01 | 0.01 | 48 |

Source: National Aeronautics and Space Administration Procurement Reports and NASA computer tabulations of subcontracts by place of performance. (Some minor adjustments and corrections were made to above data.)

Table 10

Cumulative Percent of Value of Prime Contract Awards
and Cumulative Percent of Net Work Performed, Fiscal Year 1964

| State (Ranked By Value of Prime Contracts) | Cumulative Percent: Prime Contract Awards | Cumulative Percent: Net Work Performed | State (Ranked By Value of Prime Contracts) | Cumulative Percent: Prime Contract Awards | Cumulative Percent: Net Work Performed |
|---|---|---|---|---|---|
| California | 49.1 | 45.2 | Arizona | 99.5 | 97.7 |
| Louisiana | 57.7 | 52.8 | Georgia | 99.6 | 97.8 |
| Missouri | 65.7 | 57.1 | Indiana | 99.7 | 98.2 |
| New York | 72.9 | 61.6 | Tennessee | 99.8 | 98.3 |
| Alabama | 77.2 | 65.8 | New Mexico | 99.8 | 98.4 |
| Texas | 81.40 | 70.2 | North Carolina | 99.8 | 98.4 |
| Florida | 85.6 | 75.7 | Oklahoma | 99.9 | 98.6 |
| Maryland | 87.5 | 77.8 | West Virginia | 99.9 | 98.6 |
| New Jersey | 89.2 | 80.8 | Oregon | 99.9 | 98.6 |
| Ohio | 90.7 | 82.8 | New Hampshire | 99.9 | 98.7 |
| Pennsylvania | 92.1 | 86.4 | Delaware | 99.9 | 98.7 |
| Massachusetts | 93.4 | 88.6 | Iowa | 100.0 | 99.8 |
| Wisconsin | 94.7 | 89.9 | Nevada | * | 99.9 |
| District of Columbia | 95.8 | 91.0 | Mississippi | * | 99.9 |
| Virginia | 96.6 | 91.8 | Rhode Island | * | 99.9 |
| Washington | 97.4 | 92.7 | Utah | * | 99.9 |
| Minnesota | 98.1 | 94.5 | Arkansas | * | 99.9 |
| Connecticut | 98.7 | 96.1 | Idaho | * | 99.9 |
| Colorado | 98.9 | 96.4 | Alaska | * | 99.9 |
| Illinois | 99.2 | 97.0 | Vermont | * | 100.0 |
| Michigan | 99.4 | 97.4 | Kansas | -- | 100.0 |

* Less than 0.01 percent

Source: Table 9

The relative concentration of primes (with 10 states receiving slightly over 90 percent of the value—and California dominating with 49 percent) means relatively few points of origin for subcontracts. As indicated by the data in Table 9, the origin of subcontracts is closely correlated with the value of the prime awards. The geographic pattern of actual work performed is a function of what occurs in a few states. The importance of including first- and second-tier subcontracting is indicated by the change in rankings as one moves to net work. For example, Missouri, the third ranking state in value of prime contract awards dropped to seventh in terms of work performed, and Iowa moves from thirty-three to sixteen in rank. A graphic presentation of the effect on state rankings of expanding the prime contract state allocation is shown in Chart 4.

No matter what value metric is used—prime awards or awards adjusted for subcontracts—California is the giant among states. The difference in measurement does result in lowering California's absolute and relative amounts, but the loss through subcontracts was only approximately 8 percent in fiscal 1964. The corollary of California's dominance is that other geographic units are heavily dependent on California firms' subcontracting patterns. (This point is further developed below.) Given these geographic patterns, we can ask whether there are valid economic reasons for their existence, or whether they represent the outcome of political pressures. The next section throws some light on this question.

Dollar Amt. Work Done in State (Net) ($000,000)
Fiscal Yr. '64 - Top 16 States (and Calif.)

Dollar Amt. Prime Awards ($000,000)
Fiscal Yr. '64 - Top 16 States (and Calif.)

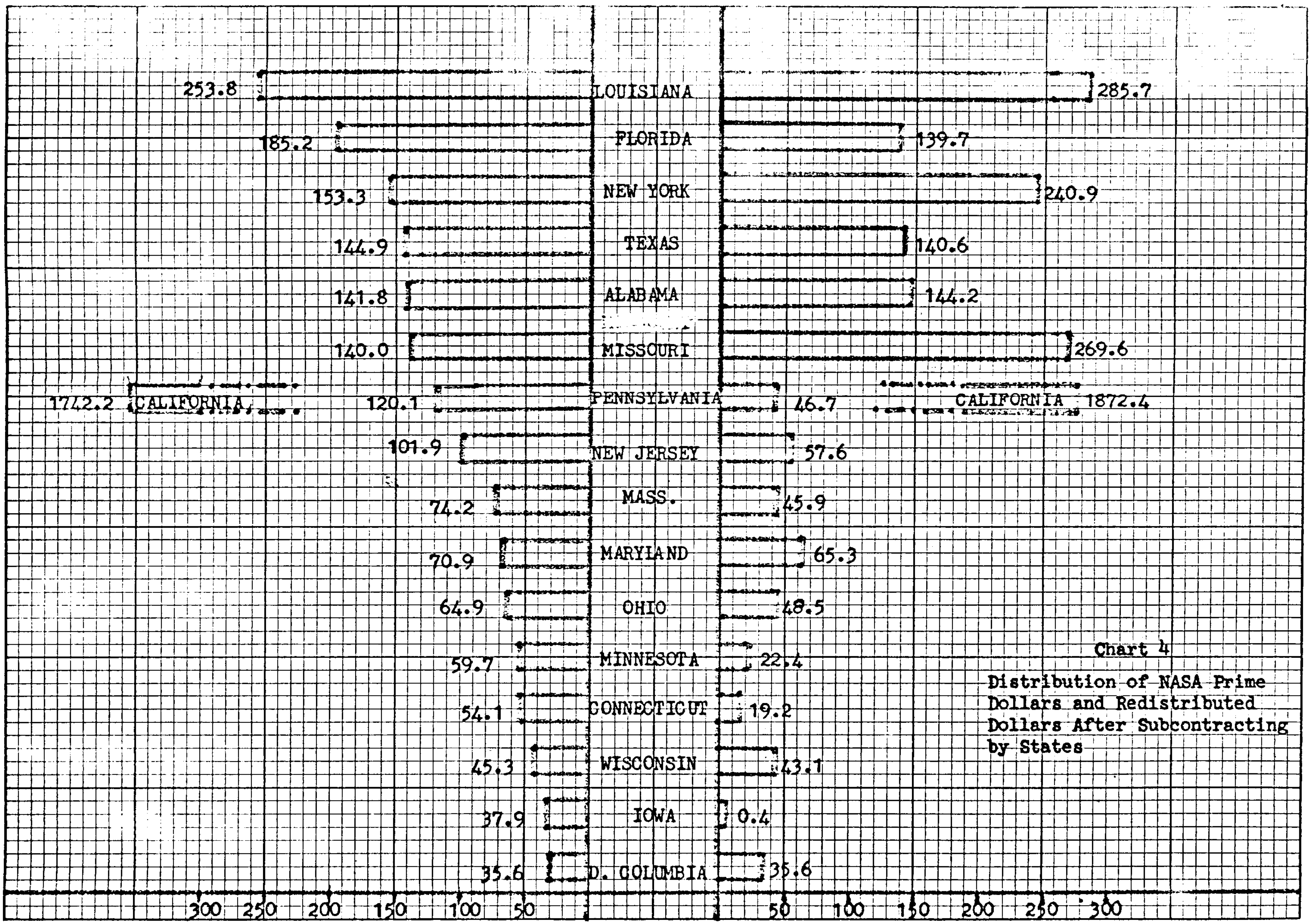



Chart 4

Distribution of NASA Prime Dollars and Redistributed Dollars After Subcontracting by States

Source: FY '64 Procurement Report

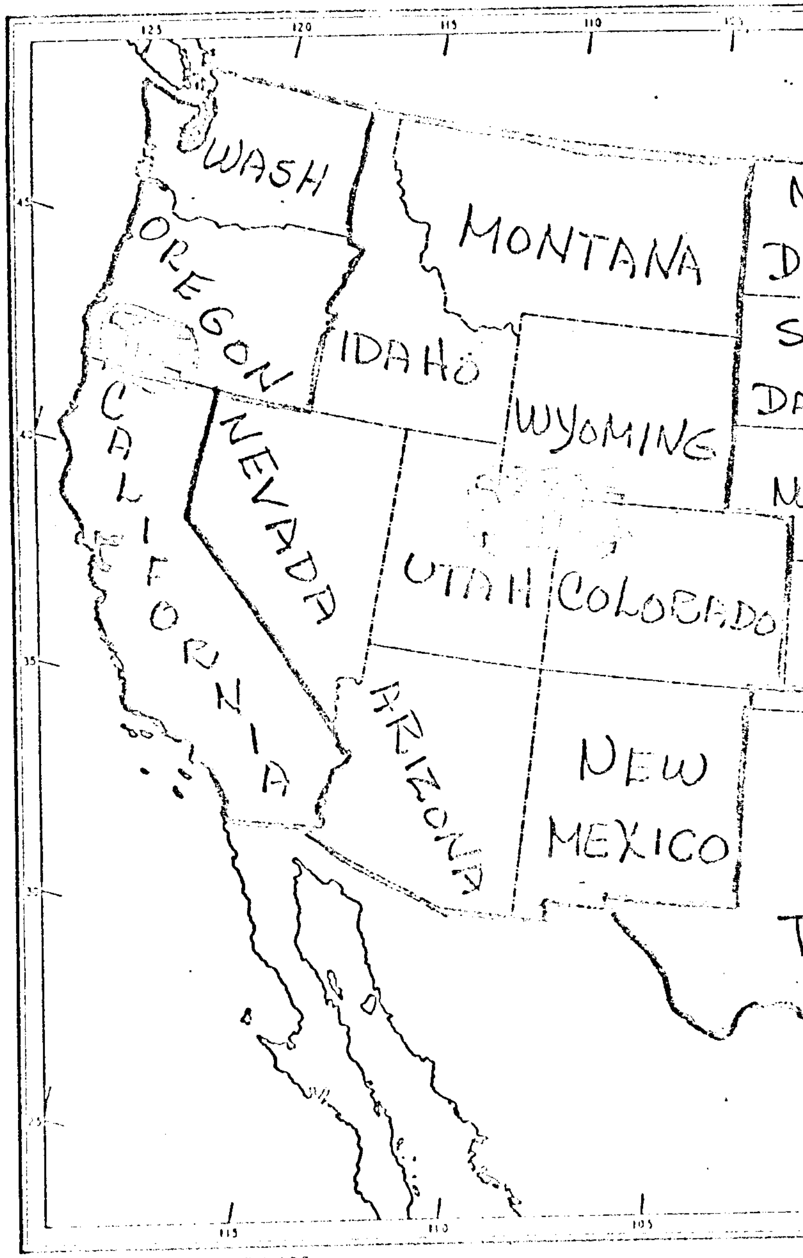
Regional Flows of First-Tier Subcontracts

That there are different economic regions in the United States is an accepted fact; that there is a unique way of operationally grouping units into regions, is not. The definition of regions used here (see Chart 5, Table 11) is a conventional one used by the U.S. Bureau of the Census. One advantage is that it can be compared with other aggregative data.

The data in the following tables are organized so as to focus on questions of point-of-origin and point-of-destination, and on the pattern of regional linkages, if any. They are in matrix form, the rows showing the distribution of subcontracts from region of origin and the columns the regional sources of subcontracts. The data cover the period from January, 1962, through December, 1964. The data for January-June, 1962, period were covered after the fact and their comprehensiveness is questionable. In fiscal 1965, the coverage of primes was expanded from 12 to 64 so as to introduce a new universe of subcontracting patterns. However, for the first six months of that fiscal year, the original 12 primes accounted for approximately 84 percent of first-tier subcontract awards. Consequently, the coverage bias is minor. Several observations may be made from Tables 12 and 13. The overwhelming influence of the Pacific region, practically synonymous with California in the time period covered, is again apparent. The South Atlantic region is the only one that derives less than one-fifth of its first-tier subcontracts from the Pacific. There is little relationship between the percent of first-tier subcontracts that originate in a region and the percent of the same total that flow into the region. A Spearman


REGIONS:-
I - NEW ENGLAND
II - MID-ATLANTIC
III - EAST-NORTH CENTRAL
IV - WEST-NORTH CENTRAL
V - SOUTH ATLANTIC
VI - EAST-SOUTH CENTRAL
VII - WEST-SOUTH CENTRAL
VIII - MOUNTAIN
IX - PACIFIC


Chart 5. U.S




GOODE'S SERIES OF BASE MAPS

Regions and Component States

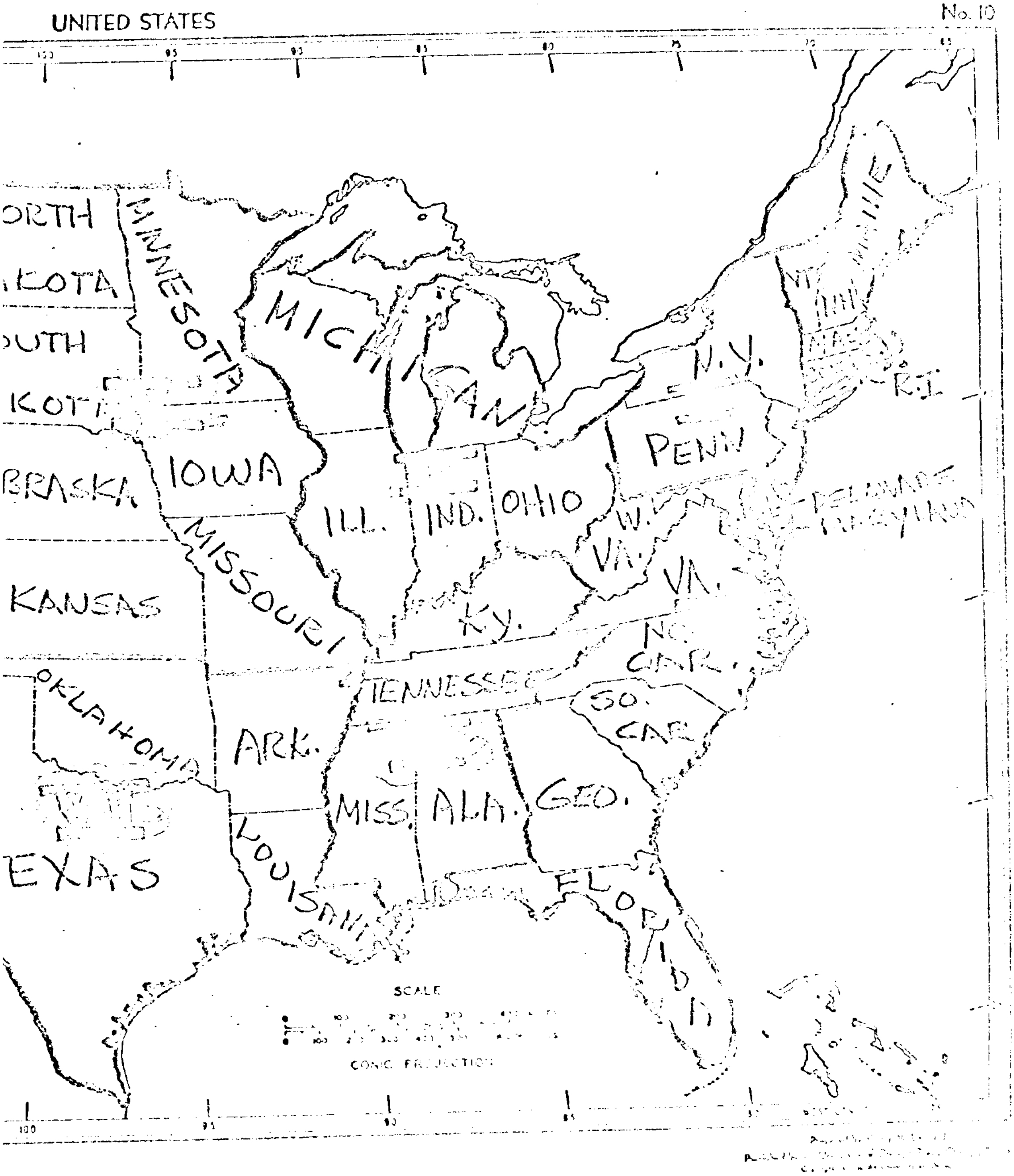


Table 11

U.S. Regions and Component States

New England
- Maine
- New Hampshire
- Vermont
- Massachusetts
- Rhode Island
- Connecticut

Mid-Atlantic
- New York
- New Jersey
- Pennsylvania

East North Central
- Ohio
- Indiana
- Illinois
- Michigan
- Wisconsin

West North Central
- Minnesota
- Iowa
- Missouri
- North Dakota
- South Dakota
- Nebraska
- Kansas

South Atlantic
- Delaware
- Maryland
- District of Columbia
- Virginia
- West Virginia
- North Carolina
- South Carolina
- Georgia
- Florida

East South Central
- Kentucky
- Tennessee
- Alabama
- Mississippi

West South Central
- Arkansas
- Louisiana
- Oklahoma
- Texas

Mountain
- Montana
- Idaho
- Wyoming
- Colorado
- New Mexico
- Arizona
- Utah
- Nevada

Pacific
- Washington
- Oregon
- California
- Alaska
- Hawaii

Table 12

Origin and Destination of First-
January 1962 - December

(in thousands of doll

| | New England | Middle Atlantic | East-North Central | West-North Central | South A |
|---|---|---|---|---|---|
| New England | 877 | 966 | 356 | 158 | 1,59 |
| Middle Atlantic | 27,012 | 97,115 | 9,541 | 2,701 | 9,83 |
| East-North Central | 259 | 2,151 | 4,713 | 70 | 50 |
| West-North Central | 31,579 | 65,751 | 9,594 | 30,773 | 102,38 |
| South Atlantic | 1,705 | 5,323 | 2,345 | 219 | 8,59 |
| East-South Central | 938 | 1,478 | 2,200 | 354 | 7 |
| West-South Central | 5,611 | 6,911 | 10,608 | 7,624 | 11,71 |
| Mountain | -- | -- | -- | -- | -- |
| Pacific | 96,866 | 148,475 | 61,640 | 172,062 | 18,85 |
| Total | 164,847 | 328,170 | 100,997 | 213,961 | 153,56 |

Source: National Aeronautics and Space Administration computer tabulations of first-tier

III-33-1

er Subcontracts
964
s)

| ntic | East-South Central | West-South Central | Mountain | Pacific | [illegible] |
|---|---|---|---|---|---|
| | 43 | 227 | 13 | 819 | [illegible] |
| | 689 | 1,535 | 300 | 69,458 | [illegible] |
| | -- | -- | 41 | 432 | [illegible] |
| | 51 | 2,037 | 10,314 | 139,416 | [illegible] |
| | 2,314 | 12 | 201 | 6,764 | [illegible] |
| | 3,807 | 4,898 | 23 | 947 | [illegible] |
| | 10,444 | 36,023 | 1,050 | 35,381 | [illegible] |
| | -- | -- | 25 | 30 | [illegible] |
| | 6,171 | 13,487 | 30,059 | 642,[illegible] | [illegible] |
| | 23,519 | 58,219 | 42,0[illegible] | [illegible] | [illegible] |

ubcontracts (with minor adjustments) by place of performance.

III-33-2

[redacted] Ta[redacted] 13[redacted]

Relative Distribution of First-Tier S
Region of Origin and Destination-- January

(in percent)

| | New England | Middle Atlantic | East-North Central | West-North Central | South At |
|---|---|---|---|---|---|
| New England | 17.3 / 0.5 | 19.1 / 0.3 | 7.0 / 0.4 | 3.1 / 0.1 | 1.0 |
| Middle Atlantic | 12.4 / 16.4 | 44.5 / 29.6 | 4.4 / 9.4 | 1.2 / 1.3 | 6.4 |
| East-North Central | 3.2 / 0.2 | 26.3 / 0.7 | 57.7 / 4.7 | 0.9 / * | 0.3 |
| West-North Central | 8.1 / 19.2 | 16.8 / 20.0 | 2.4 / 9.5 | 7.9 / 14.4 | 66.7 |
| South Atlantic | 6.2 / 1.0 | 19.4 / 1.6 | 8.5 / 2.3 | 0.8 / 0.1 | 5.6 |
| East-South Central | 6.4 / 0.6 | 10.0 / 0.4 | 15.0 / 2.2 | 2.4 / 0.2 | * |
| West-South Central | 4.5 / 3.4 | 5.5 / 2.1 | 8.5 / 10.5 | 6.1 / 3.6 | 7.6 |
| [illegible] | -- / -- | -- / -- | -- / -- | -- / -- | -- |
| [illegible]fic | 8.1 / 58.7 | 12.5 / 45.3 | 5.2 / 61.0 | 14.5 / 80.4 | 12.3 |
| To[illegible] 1/ | 8.3 | 16.6 | 5.1 | 10.8 | 7.8 |

* [illegible] 0.05 percent

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...bcontracts by
...962 - December 1964

| ...antic | East-South Central | West-South Central | Mountain | Pacific | Tot... |
|---|---|---|---|---|---|
| ...1.6 | 0.8 / 0.2 | 4.5 / 0.4 | 0.3 / * | 16.2 / 0.1 | 0.3 |
| ...4.5 | 0.3 / 2.9 | 0.7 / 2.6 | 0.1 / 0.7 | 31.8 / 7.8 | 11.[illegible] |
| 6.2 | -- / -- | -- / -- | 0.5 / 0.1 | 5.3 / * | 0.[illegible] |
| ...6.1 | * / 0.2 | 0.5 / 3.5 | 2.6 / 24.5 | 35.6 / 15.6 | 19.[illegible] |
| ...1.3 | 8.4 / 9.8 | -- / * | 0.7 / 0.5 | 2[illegible].6 / 0.8 | [illegible] |
| 0.5 | 25.9 / 16.2 | 33.3 / 8.4 | 0.2 / 0.1 | 6.4 / 0.1 | [illegible] |
| 9.4 | 8.3 / 44.4 | 28.7 / 61.9 | 0.8 / 2.5 | 28.2 / 4.0 | [illegible] |
| -- | -- / -- | -- / -- | 45.4 / 0.1 | [illegible] / -- | |
| 1.6 | 0.5 / 26.2 | 1.1 / 23.2 | 2.5 / 71.5 | 54.0 / 74.7 | [illegible] |
| | 1.2 | 2.9 | 2.1 | 45.[illegible] | 1[illegible] |

III-34-2

Table 13—Continued

The upper figures show distributions across the rows; the relative flows from the lower figures show the relative inflows into the region. The "total column" indicates the relative contribution to the origin of flows; the "total row" the relative contribution to inflows or destination. For example, the 60.0 percent for the Pacific region in the total column indicates that 60 percent of first-tier subcontracts originated in this region. The 45.2 percent in the total row indicates that this percent of all first-tier flows had this region as the destination.

Source: Table 12

rank correlation between in- and out-percentages for the regions results in a coefficient of 0.68, barely significant at the .05 level. Excluding California, the regression coefficient drops to 0.55 which is not significant at that level. A possible inference from this is that such elements as transport costs, closeness to market, and closeness to the "satellite firm" are not important to the geographic pattern of work. This is analogous to the problem of "cross-hauling" in regional analyses, i.e., the observation that apparently comparable goods are both imported into and exported from a region.

Herein lies an apparent paradox. Looking at the principle diagonal in Table 13—the intraregion flows—in several of the nine regions, these flows represent a greater percentage of outflows than inflows. At least square regression (N = 9) between intraregional and total regional outflows yields in a regression coefficient of 0.96 significant at the .01 level. Repeating the computation on a state level (N = 24), since one can argue that the region is too aggregative, the regression coefficient remains virtually unchanged. (In both cases the slope of the regression line is $44^{\circ}$ on "log-log paper.") These results seem to indicate that a state (region) feeds on itself insofar as flows from prime contractor to first-tier subcontractor. (The second-tier subcontractor is undoubtedly more geographically tied but the NASA subcontractor data are not usable for testing this hypothesis.) Consequently, distance from prime would appear to be important for subcontracting.

The apparent paradox may well be explained in the same way that cross-hauling is explained—namely, that we are dealing with different "products." We mentioned previously that competition in the aerospace field tends towards technological competition. This competition has a partial geographic overlay to it. For example, the Boston area is marked as the electronics area; Missouri has the Gemini payload; California has the Apollo payload and some large diameter motor effort. In other words, certain subsystems for NASA programs have certain areas that predominate. To this extent, primes in these areas have satellite work in close proximity. This may explain the intrastate (regional) flows.

Looking at this technological-geographical combination in another way we refer back to two statements previously made regarding the significant overlap between the set of primes and the set of first-tier subcontractors, and the manner in which many first-tier subcontractors appear, over time, as performing similar tasks for different primes. One inference, then, is that subcontracts tend to flow to firms and areas of special competence. This then, could explain the failure of distance to act as a correlative factor in first-tier inflows, while at the same time explaining the large volume of intraregional flows.

## IV. APPLICATIONS OF THE SUBCONTRACTOR REPORTING SYSTEM: REGRESSION ANALYSIS

Our applications of NASA generated data to this point have described the prime contractor and subcontractor universes starting with a selected set of prime contractors and eventually building up, on a geographic basis, to the intra- and interregional subcontract flows. Certain important inferences, such as the degree of overlap between the sets of prime contractors and subcontractors, the geographic network of subcontracting, and the geographic spreading out of prime contracts through subcontracts were highlighted. The applications effort is continued in this section by attempting to statistically "explain" the variations in the geographic distribution of work performed for NASA.

We selected an approach that involves the techniques of simple regression, factor analysis, and multiple regression, performed in that order. Our primary objective is to test for positive association between NASA awards by state (dependent variable) and thirteen selected economic or demographic measures (independent variable). The time period covered by the analysis is calendar years 1963 and 1964, and is limited to the original twelve prime contractors in order to maintain a consistent universe.[1]

The tests for association are, in reality, variations on the same theme. The computation sequence started with simple correlation, which tests for the covariance between two variables, allowing all other variables in the universe to vary freely. Factor analysis then operates on the matrix

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1. See Section III, Tables 3 and 4.

of simple correlation coefficients between the independent variables, "factoring" this matrix into a set of linear equations with the various factors treated as the new independent variables. The coefficients of these factors for each variable test the association between that variable and each factor, with each successive factor "explaining" an increasing portion of the total variance of estimates between the various states. Consequently, the number of independent variables used in the analysis can be reduced by selecting the variable with the highest coefficient for each factor as being representative of all the variables that are highly correlated with that factor.

The third and final variation on the "associative" theme is multiple regression. Multiple regression attempts to isolate the linear relationship between the dependent variable and each of the independent variables separately. In other words, as used here, a linear relationship is established between the dependent variable and the set of representative independent variables found by factoring their covariance matrix. Each coefficient is estimated by the method of least squares holding the other independent variables constant.

## Selection of Variables

Dependent variables. Since the purpose of the analysis is to "explain" state variations in work performed for NASA, the choice for measuring the dependent variable turned on appropriate proxy measures. Two different measures were selected, reflecting the universes of actual total performance and of subcontracts performed. Total performance—termed net work performed—for each state was obtained in the following way: the value of subcontracts received by the state was added to the prime contracts awarded and then the value of subcontracts flowing out of the state was subtracted. The resultant was a measure of the actual amount of NASA work (in dollars) contracted during the 1963-64 period in each state. The estimates for subcontracts received over the period of analysis was obtained from NASA computer runs which have been kept on a quarterly basis since January, 1962. A discussion of the reliability of the subcontractor data has been presented previously and is not repeated here.

Both dependent variables are, in a sense, proxy measures, since there are both value cutoffs and omissions of specified tasks performed in the collection systems for prime contract and subcontract awards. As has been pointed out above, net work performed (NWP) is a more accurate measure of actual work done in a state than the usual way of looking solely at prime contract awards. We would also expect tests of association with the selected independent variables to have more meaning (although not necessarily yield more significant results) when NWP is the dependent variable than when subcontract awards is used.

Independent variables. Given access to high speed digital computers and available "software," the analyst would be amiss if regression analysis were not used for hypothesis seeking as well as hypothesis testing. After all, what correlation analysis does is to show whether variables, as a matter of actual experience, have varied together linearly, and if so, the significance of such a relationship. However, a relationship that cannot be explained in terms of observations from the relevant field of knowledge and theory, but rests solely on empirical association, leaves much unanswered. Any choice of variables, however, is to a large extent a subjective matter.

Much of our conceptual approach to the selection of the thirteen independent variables used stems from our explorations described in

Section III. That Section contains several comments on a technological network tying together the various firms performing tasks for the civilian space program. If that analysis is correct, then one may postulate a specialized capability requirement for work performance, at least for prime contractors. However, with the significant overlap for firms awarded both prime and subcontracts, the same hypothesis covers both universes. Variables selected as proxies for specialized capability are:

(1) Number of physicists and astronomers.

(2) Percent of nation's engineers residing in state.

(3) Number of persons enrolled in higher education.

These variables are proxies representing specialized disciplines required for space work, as well as communities of scholars and basic research facilities in proximity to space firms. They are also indicative of what "have not" areas are striving to obtain.

A counter hypothesis to specialized areal capabilities could be that generalized capability to conduct research and development and the necessary fabrication for space systems is sufficient for NASA contractual activity. Proxy variables chosen to represent this factor are:

(1) Total employees in manufacturing establishments.

(2) Employees in private nonagricultural establishments.

(3) State expenditures.

(4) Capital expenditures by manufacturing establishments.

(5) Value added by manufacturing establishments.

With the exception of state expenditures, the listed variables are chosen to represent a spectrum of general resources either in manufacturing or in private productive activity. They also cover both processing and income generation. State expenditures was selected as a proxy for the degree of infrastructure and general education, since "amenities" are thought to be, by some individuals, an important factor in attracting aerospace activities. Infrastructure outlays may contribute to such "amenities" of life. As was suspected, further analysis yielded evidence of considerable intercorrelations between the above variables, and between them and the "specialized proxy" variables.

Consideration was given to other hypotheses concerning the locational aspects of space activity. These concerned questions of income (personal income per capita, and wages and salaries per employee in manufacturing establishments); possible association with state economic growth (state growth rate, state per capita growth rate); and, since the dependent variable was not feasible for units below the state level, percent of state population in standard metropolitan statistical areas (SMSA) as an urban proxy for individual SMSA's.

## Simple Correlation

As mentioned above, in simple correlation we test the covariance of two random variables through making observations on distinct data points and allowing all other variables in the universe to fluctuate freely. To test for simple correlation, models using subcontract awards and those using net work performed were run separately against each of the thirteen independent variables described above. Three cases were constructed: a full sample for the continental United States (48 states plus the District of Columbia), a sample of 48 (since California is the recipient of almost one-half NASA work, it is excluded as a statistical "outlier"), and a sample of 46 states with the dependent variable reduced to natural logarithms. Thus, the parameters of 78 equations—6 models, 13 equations each—were estimated.

(See Table I Statistical Appendix to this Section for detailed results.)

Net Work Performed

Results of the Analysis for measures of association between net work performed (NWP) and each of the selected independent variables are summarized in Table 14. Testing at the 0.01 level of significance for all 49 data points, the null hypothesis (the presence of no correlation), was accepted in five of the thirteen equations. The five variables accepted—percent of state population in SMSA, wages and salaries per employee in manufacturing, personal income per capita, state growth rate, and state growth rate per capita—have relatively narrow bands of variation as compared to the wide range of variation in NWP. In part, the narrower band is due to normalizing for the population.

Only a relatively small part of the variance is explained by any of the selected variables, the maximum amount being about 60 percent. Only four variables explain one-half or more of the variance, with the fifth "best" variable explaining approximately 30 percent. In the net work performed case for all 49 data points, the results are consistent with both the "specialized capability" and the "general capability" hypotheses concerning the state distribution of activity.

The elimination of California (using 48 data points) resulted in lowering the coefficient of determination ($R^2$) in 12 of the 13 equations, with a shift in ranking variables as to "explanatory power." The only one to be raised was the urbanization variable, percent of state population in SMSA's, which now became marginally significant at the .01 level. The other four variables mentioned above as not significant at the .01 level with California, remained insignificant. The statistical effect of

Table 14

Net Work Performed: Selected Regression Statistics

(one variable at a time)

| Independent Variable | R I N=49 | R II N=48 | R III N=46 | $R^2$ I N=49 | $R^2$ II N=48 | $R^2$ III N=46 |
|---|---|---|---|---|---|---|
| 1. Number enrolled in higher education | 0.78 | 0.50 | 0.56 | 0.61 | 0.25 | 0.32 |
| 2. Number of physicists and astronomers | 0.73 | 0.45 | 0.53 | 0.53 | 0.20 | 0.28 |
| 3. Percent of engineers | 0.72 | 0.48 | 0.58 | 0.52 | 0.23 | 0.34 |
| 4. State expenditures | 0.71 | 0.53 | 0.54 | 0.50 | 0.29 | 0.30 |
| 5. Employees in private nonagricultural establishments | 0.54 | 0.50 | 0.56 | 0.29 | 0.25 | 0.31 |
| 6. Capital expenditures by manufacturing establishments | 0.49 | 0.38 | 0.50 | 0.24 | 0.15 | 0.25 |
| 7. Value added by manufacturing establishments | 0.47 | 0.40 | 0.51 | 0.22 | 0.16 | 0.26 |
| 8. Total employees in manufacturing establishments | 0.43 | 0.40 | 0.50 | 0.19 | 0.16 | 0.25 |
| 9. Percent of state population in SMSA's | 0.30 | 0.41 | 0.62 | 0.09 a/ | 0.17 | 0.39 |
| 10. Wages and salaries per employee in manufacturing | 0.23 | 0.12 | 0.36 | 0.05 a/ | 0.01 a/ | 0.13 a/ |
| 11. Personal income per capita | 0.23 | 0.12 | 0.39 | 0.05 a/ | 0.02 a/ | 0.15 |
| 12. State growth rate (1948-63) | 0.19 | 0.17 | 0.21 | 0.04 a/ | 0.03 a/ | 0.04 a/ |
| 13. State growth per capita rate (1948-63) | 0.03 | 0.24 | 0.27 | a/b/ | 0.06 a/ | 0.07 a/ |

a. Not significant at 0.01 level
b. Less than 0.005

I All continental United States
II Excluding California
III Logarithmic form excluding California

Source: See Statistical Appendix, Section IV.

California is amply indicated by its dominance, as indicated in Table 15. Whereas California receives approximately half the net work performed, Louisiana, ranked number two, receives only slightly more than seven percent. The top ten states account for almost 85 percent of the total recorded activity.

Two technical problems arose when Case II (excluding California) was converted to a logarithmic form. First, the computer regression program used requires a conversion from the decimal value to its natural log equivalent. When the computer attempts to convert a zero value, that particular observation is deleted from the sample. Consequently, since North Dakota and Nebraska received neither prime contracts nor subcontracts, the sample size was reduced from 48 data points to 46. Thus, some information was lost in the conversion process. Secondly, the effect of log conversion must be considered. Holding the sample size constant, if the relationship between net work performed and the independent variable is actually linear, a conversion to natural logarithms will reduce the slope of the regression line but have only a minor effect on the correlation coefficient. However, if the relationship is approximately exponential ($Y = ae^{bx}$), then the correlation coefficient is raised significantly. In both cases, the conversion reduces the slope of the regression line and thus the possible range of Y values observed.

Running the log case correlations (excluding California), we find that the coefficient of determination ($R^2$) increases for all thirteen variables (as expected). That is, more of the variance in the dependent variable is explained by this form. Variables whose relationship with NWP (their $R^2$) increased significantly were per capita income, wages and salaries per employee in manufacturing, and the measure of urbanization.

Table 15

Top Ten States: Fiscal Years 1963 and 1964
Amount of Net Work and Amount of Subcontracts

(in millions of dollars)

| | Net Work | | | | Subcontracts | | | |
|---|---|---|---|---|---|---|---|---|
| | Dollars | Percent | Rank | Population Rank | Dollars | Percent | Rank | Population Rank |
| California | 2,932 | 50.3 | 1 | 1 | 591 | 45.3 | 1 | 1 |
| Louisiana | 430 | 7.4 | 2 | 19 | a/ | a/ | a/ | a/ |
| Florida | 277 | 4.8 | 3 | 9 | 53 | 4.0 | 7 | 9 |
| New York | 267 | 4.6 | 4 | 2 | 86 | 6.6 | 3 | 2 |
| Alabama | 236 | 4.0 | 5 | 21 | a/ | a/ | a/ | a/ |
| Texas | 199 | 3.4 | 6 | 5 | a/ | a/ | a/ | a/ |
| Pennsylvania | 180 | 3.1 | 7 | 3 | 106 | 8.1 | 2 | 3 |
| New Jersey | 162 | 2.8 | 8 | 8 | 51 | 3.9 | 9 | 8 |
| Maryland | 123 | 2.2 | 9 | 20 | a/ | a/ | a/ | a/ |
| Massachusetts | 120 | 2.1 | 10 | 10 | 52 | 4.0 | 8 | 10 |
| Minnesota | a/ | a/ | a/ | a/ | 69 | 5.3 | 4 | 17 |
| Connecticut | a/ | a/ | a/ | a/ | 61 | 4.7 | 5 | 24 |
| Iowa | a/ | a/ | a/ | a/ | 54 | 4.2 | 6 | 25 |
| Ohio | a/ | a/ | a/ | a/ | 26 | 2.0 | 10 | 6 |
| Total | 4,936 | 84.5 | -- | -- | 1,148 | 88.0 | -- | -- |

a. Not in first ten

Source: National Aeronautics and Space Administration Procurement Reports and NASA computer tabulations of subcontracts by place of performance.

This was to be expected, since these were the variables most likely to be related to NWP by the exponential form. The rough measure of spread—the range of Y values divided by the standard error of their estimate—is the smallest of the three cases in the logarithmic form. Apparently, in the cases cited above, the exponential form is more appropriate than the linear.

If the independent variables are ranked by the ordering of $R^2$, the following interesting subset appears:

| | Rank $R^2$ | | |
|---|---|---|---|
| | Case I (N=49) | Case II (N=48) | Case III (N=46) |
| Number enrolled in higher education | 1 | 2 | 3 |
| Number of physicists and astronomers | 2 | 5 | 6 |
| Percent of engineers | 3 | 4 | 2 |
| State expenditures | 4 | 1 | 5 |
| Employees in private nonagricultural establishments | 5 | 2 | 4 |

With one exception, these variables are within the five highest orderings. (In the log case, the highest ranking variable is "percent of state population in SMSA's" which ranks 9th in the California case and 6th in the other nonCalifornia case.)

Does this subset of independent variables make "sense" in relation to the dependent variable? It does reinforce, in both the California and non-California cases, what is generally believed about the geographic location of advanced space technology. That is, NASA net work performed is associated with states having larger concentrations of engineers and physicists, college enrollees, manufacturing and supportive services and large public outlays. (A priori, as well as after verification from factor analysis, it is apparent that the five variables are highly correlated with one another, and this factor is discussed below.)

There is an intimate relation between the conduct of research and the provision of higher education in science engineering. National science and national education policy interface because of this relationship. Experience shows that applied research and development efforts focused on practical problems benefit from close association with basic research efforts. In addition, changing technology and changing skill requirements involve the continual education of scientists and engineers. It is not surprising that this complex is viewed as a focal point for growth by various regions. It is also reasonable to expect these variables to show up as important factors in the type of analysis carried on here.

This scientist-engineer-higher education complex is of further interest, since it has become a syndrome for the "have not" areas in research and development and they are pushing to increase activities in these areas. One should not necessarily credit aerospace activities as the main cause of development of such complexes, but the quotation from Harry Johnson's provocative piece cited above, should be kept in mind.

State expenditures as a relatively high explanatory variable is an interesting one and requires exploration beyond the scope of this report. (It emphasizes the role that this type of analysis may play in generating hypotheses for further exploration.) Sheer magnitude of population is important since seven of the top ranking states in amount of net work performed are in the first ten most populous states. However, among the top NASA ten are Louisiana, Maryland, and Alabama, with population rankings of nineteen, twenty and twenty-one, respectively. (The top ten account for 85 percent of NWP; California alone, accounts for 50 percent of the total. See Table 15.)

Subcontracts Received

The simple correlations for subcontracts received on a state basis were computed under the same format (see Table 16 and Appendix). In general, the results for subcontract awards parallel those for net work performed. (See Tables 14 and 16.) Because of the overlap of firms as prime contractors and as subcontractors, this parallelism of results is not surprising. There are, however, some technical differences.

For most of the independent variables considered, the $R^2$ are higher for subcontracts alone than for net work performed. The rank order of states according to subcontracts received differs from that for NWP (see Table 15). Although California also dominates the subcontractor universe, its relative share is 45 percent rather than the 50 percent in net work performed. As mentioned previously, consideration of subcontracts tends to geographically spread out the work. The more general geographic and value spreads of subcontracts results in a more linear clustering of data points. The range test values (range of Y/standard error of estimate) fall significantly from those obtained previously.

The same five independent variables—number enrolled in higher education, number of physicists and astronomers, percent of engineers, state expenditures, and employees in private nonagricultural establishments—are again the more relevant ones in the subcontracts computations. However, in the two nonCalifornia cases, their rank order differs from those in the net work performed cases. Interestingly enough, for subcontracts, independent variables for manufacturing employment and value added, rank relatively higher in explaining the variance. Again, this phenomenon is due to the effect of the more general and relatively more even spread of subcontracts.

Table 16

Subcontract Awards: Selected Regression Statistics

(one variable at a time)

| Independent Variable | R I N=49 | R II N=48 | R III N=44 | $R^2$ I N=49 | $R^2$ II N=48 | $R^2$ III N=44 |
|---|---|---|---|---|---|---|
| 1. Number enrolled in higher education | 0.82 | 0.64 | 0.59 | 0.67 | 0.41 | 0.35 |
| 2. Number of physicists and astronomers | 0.79 | 0.69 | 0.52 | 0.62 | 0.47 | 0.27 |
| 3. Percent of engineers | 0.77 | 0.66 | 0.63 | 0.59 | 0.44 | 0.40 |
| 4. State expenditures | 0.75 | 0.63 | 0.58 | 0.56 | 0.40 | 0.33 |
| 5. Employees in private nonagricultural establishments | 0.60 | 0.67 | 0.60 | 0.36 | 0.45 | 0.36 |
| 6. Capital expenditures by manufacturing establishments | 0.55 | 0.55 | 0.56 | 0.30 | 0.30 | 0.31 |
| 7. Value added by manufacturing establishments | 0.55 | 0.61 | 0.58 | 0.30 | 0.37 | 0.33 |
| 8. Total employees in manufacturing establishments | 0.52 | 0.65 | 0.56 | 0.27 | 0.42 | 0.32 |
| 9. Percent of state population in SMSA's | 0.35 | 0.51 | 0.73 | 0.13 a/ | 0.26 | 0.54 |
| 10. Personal income per capita | 0.31 | 0.37 | 0.42 | 0.09 a/ | 0.14 | 0.18 |
| 11. Wages and salaries per employee in manufacturing | 0.27 | 0.25 | 0.41 | 0.07 a/ | 0.06 a/ | 0.17 |
| 12. State growth rate (1948-63) | 0.16 | 0.01 | 0.22 | 0.02 a/ | a/b/ | 0.05 a/ |
| 13. State growth per capita rate (1948-63) | 0.09 | 0.03 | 0.06 | 0.01 a/ | a/b/ | a/b/ |

a. Not significant at 0.01 level
b. Less than 0.005

I All continental United States
II Excluding California
III Logarithmic form excluding California

Source: See Statistical Appendix, Section IV.

Finally, it might be noted that there are four states which receive no subcontracts (as to two receiving no NWP)—Nebraska, North Dakota, Montana, and Wyoming. This loss of two additional data points from the sample states with relatively low levels of manufacturing and urbanization, would explain a portion of the increased $R^2$ for the subcontracts log case over that for net work performed.

## Factor Analysis

The use of factor analysis here was as an intermediate step between simple and multiple regression. It is a technique that provides some objective basis for synthetically condensing measurements of a number of characteristics ("attributes") of states, since we suspect that many of these characteristics are closely related.

Factor analysis was applied to the 13 x 13 covariance matrices of independent variables for both the sample of 48 states, plus Washington, D.C., and the sample excluding California (see Tables 14 and 16).[2] The results for the samples of 49 and 48 states are shown in Table 17. The nature of factor analysis is such that factors will be extracted as long as computations are made. Computations were stopped after extracting the fifth factor with approximately 95 percent of the variance explained. From the resulting matrices, it is evident that the similarities of factors are such that the same underlying forces are being measured when California is excluded as when it is included. Although the relevant loadings (coefficients $> 0.5$) are higher in the nonCalifornia case, the differences are marginal.

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2. For a technical discussion of factor analysis see Gerhard Tinter, <u>Econometrics</u>, (New York, N.Y.: John Wiley and Sons, 1952), pp. 102-114.

| Variable | Inc Common Fa | |
|---|---|---|
| | One | Two |
| 1. Employment in private nonagr. establishments | 9672 | 1919 |
| 2. State expenditures | 9591 | 1136 |
| 3. Percent of engineers | 9485 | 2472 |
| 4. Total employees in manufacturing establishments | 9483 | 1906 |
| 5. Value added by manufacturing establishments | 9483 | 2339 |
| 6. Number enrolled in higher education | 9376 | 1740 |
| 7. Capital expenditures by mfg. establishments | 9339 | 1866 |
| 8. Number of physicists and astronomers | 8476 | 3160 |
| 9. Percent of state population in SMSA's | 3876 | 7834 |
| 10. Personal income per capita | 2192 | 9145 |
| 11. Wages and salaries per employee in mfg. | 1827 | 8342 |
| 12. State growth per capita rate (1948-63) | -0335 | -0815 |
| 13. State growth rate (1948-63) | -0064 | -1816 |
| Cumulative percent of total variance explained | 63 | 77 |

Source: Tables 14 and 16, Section IV

Table 17

Factor Loadings

| luding California ctors (loadings x $10^{-4}$) | | | Excluding California Common Factors (loadings x $10^{-4}$) | | | | |
|---|---|---|---|---|---|---|---|
| Three | Four | Five | One | Two | Three | Four | Five |
| -0355 | 0302 | 0079 | -9773 | -1525 | 0110 | -1060 | 0041 |
| 0425 | -1113 | 1359 | -9602 | -0747 | -0057 | -0861 | -0736 |
| 0505 | -0720 | 1181 | -9517 | -2580 | 0040 | -0623 | 0014 |
| -0706 | 1169 | -1461 | -9690 | -1514 | 0397 | 0181 | 0838 |
| 0005 | 0806 | -1665 | -9614 | -2061 | -0119 | 0865 | 0746 |
| 0855 | -1031 | 2166 | -9560 | -1718 | -0216 | -1194 | -0100 |
| -0009 | 0391 | -2610 | -9323 | -1635 | 0371 | 2607 | 0739 |
| -0027 | -0221 | 3871 | -7946 | -3511 | 0691 | -4339 | 0710 |
| -3428 | -0730 | 0328 | -3834 | -7677 | 3621 | -0726 | -0749 |
| 0431 | -0253 | 1377 | -1861 | -9106 | -0515 | -2030 | -0444 |
| 3539 | -1774 | -1895 | -1510 | -8628 | -2819 | 2651 | -1091 |
| -8963 | -3530 | -0101 | -0053 | 0904 | 9108 | -0098 | -3371 |
| -3516 | -9009 | 0097 | 0788 | -1727 | 3684 | 0101 | -9020 |
| 89 | 93 | 96 | 62 | 77 | 89 | 93 | 95 |

Although five factors were computed, in both cases it was found that just four of the thirteen original variables could be used for testing the significance of partial regression coefficients without loss of information. (Factor four in the nonCalifornia case and factor five in the California case yielded no significant variable, although the state growth rate appeared significant in the fifth and fourth factors, respectively.)

The first factor, which may be termed "general industrialization," combines practically all the variables previously designated as proxies for both "special capability" and "general capability." If either of these exist separately as unique "explanations" of state distribution of NASA activities, our method of analysis is too gross to discriminate between them. The techniques may be inappropriate; the geographic area too broad; or, improper variables were chosen. For each factor, with 0.5 as the significance level, the largest variable, regardless of sign, was chosen as representative of the factor.[3]

Multiple Regression

Using the independent variables derived from the factor analysis, six multiple regressions were computed using the basic models described above for simple regression analysis. The independent variables selected were: employment in private nonagricultural establishments; personal income per capita; state economic growth per capita rate; and, state economic growth rate. (Additional models were computed substituting first, percent of engineers and then number enrolled in higher education for the

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3. For a discussion of the use of factor analysis in measuring regional variations, see Bernard M. Olsen and Gerald Garb, "An Application of Factor Analysis to Regional Economic Growth," Journal of Regional Science (Summer, 1965), pp. 51-56.

employment variable above.) This resulted in 18 more equations with estimated parameters. They were tested for significance of $R^2$ and partial regression coefficients (see Table 18 and Appendix, Tables II and III). Even though the nine deleted variables are redundant in estimating partial regression coefficients (that is, raise the problem of multicollinearity), we tested whether their inclusion in the model added to the explanation of the total variance of the estimates. Thus, six additional equations were run testing for the significance of $R^2$ using all thirteen independent variables in each of the cases used in simple correlation (see Table 19).

The regression coefficients for multiple regression were estimated using least squares of the form $Y = b_0 + b_1 X_1 + \cdots + b_n X_n + u$. Least squares is used to test two general hypotheses:

(1) Do the least squares estimates explain a significant portion of the variance about the regression line (or hyperplane)? The ratio of the explained variance to the unexplained variance is the coefficient of determination ($R^2$) and its significance is measured by the F ratio.

(2) Is each of the partial regression coefficients significantly different from zero? The ratio of the estimated coefficient to its standard error is used to test for significance by the T distribution.

The conclusions drawn from the multiple regressions, including all thirteen independent variables (using the F test), are the following:

(1) When California is included in the model, the thirteen variables explain a significant (at the .01 level) percent of the variance—over 90 percent—for both net work performed and subcontracts.

(2) When California is excluded, the results are still significant at the .01 level, but the $R^2$ values (explained variance) are reduced substantially.

(3) The transformation of the dependent variable to natural logarithms (Case III) results in insignificant changes in $R^2$. The dominant relation between either measure and the selected independent variables is positive and linear.

Table 18

Multiple Regression: Selected Statistics

(Four selected variable models)

| | Net Work Performed | | | Subcontract Awards | | |
|---|---|---|---|---|---|---|
| | I<br>N=49 | II<br>N=48 | III<br>N=46 | I<br>N=49 | II<br>N=48 | III<br>N=46 |
| Model I: $R^2$ | 0.34 | 0.32 | 0.46 | 0.42 | 0.47 | 0.47 |
| | | | T test: | .01 level | | |
| Personal income per capita | - | - | - | - | - | - |
| Employees in private nonagr. establishments | + | + | + | + | + | + |
| State growth rate (1948-63) | - | - | - | - | - | - |
| State growth per capita rate (1948-63) | - | - | - | - | - | - |
| Model II: $R^2$ | 0.65 | 0.32 | 0.47 | 0.69 | 0.44 | 0.47 |
| | | | T test: | .01 level | | |
| Personal income per capita | - | - | - | - | - | - |
| Number enrolled in higher education | + | + | + | + | + | + |
| State growth rate (1948-63) | - | - | - | - | - | - |
| State growth per capita rate (1948-63) | - | - | - | - | - | - |
| Model III: $R^2$ | 0.56 | 0.30 | 0.47 | 0.62 | 0.45 | 0.49 |
| | | | T test: | .01 level | | |
| Personal income per capita | - | - | - | - | - | - |
| Percent of engineers | + | + | + | + | + | + |
| State growth rate (1948-63) | - | - | - | - | - | - |
| State growth per capita rate (1948-63) | - | - | - | - | - | - |

+ Significant at .01 level
- Insignificant at .01 level

Source: Tables II and III, Appendix of Section IV

Table 19

Multiple Regression: Selected Statistics
(13 independent variables)

| | | Net Work Performed $R^2$ | F ratio | N | Significant at .01 level |
|---|---|---|---|---|---|
| I | All Continental United States | 0.93 | 36.5 | 49 | Yes |
| II | Excluding California | 0.61 | 4.1 | 48 | Yes |
| III | Logarithmic form: excl. California | 0.63 | 4.1 | 46 | Yes |
| | | Subcontract Awards | | | |
| I | All Continental United States | 0.92 | 31.4 | 49 | Yes |
| II | Excluding California | 0.57 | 3.4 | 48 | Yes |
| III | Logarithmic form: excl. California | 0.56 | 3.0 | 46 | Yes |

Source: Statistical Appendix, Section IV

In turning to the model with the independent variables representing the four different factors isolated through factor analysis (see above), both F and T tests were computed. That is, in the latter models (since other variables from Factor I were substituted for the employment variable) we were interested in the partials. Testing for the significance of the partial regression coefficients, running various combinations (18 equations) of the selected uncorrelated variables, the following results were obtained (see Table 18):

(1) The variables correlated with Factor I (see Table 17)—employees in private nonagricultural establishments; number enrolled in higher education; and percent of the nation's engineers—are the only variables significantly (at the .01 level) related to NASA work of the factors tested.

(2) The parameters estimated using subcontracts as the dependent variable are more significant than the corresponding parameters using NWP as dependent.

(3) When California is included, there is a definite order of importance for the three variables under Factor I—enrollees in higher education, percent of engineers, and employment rank—in that order, which is the same relative ordering as in simple correlation (see Tables 14 and 16); when California is excluded, no particular relative order is noted.

(4) California's per capita growth during the 1948-63 period was such—less than the national average—that when California is included in the model the regression coefficient for per capita growth is negative; when California is excluded, that slope becomes positive and becomes significant at the .05 level in the NWP log case.

(5) The coefficient of state growth variable is positive in all cases.

(6) The coefficient of per capita income is negative in both the NWP and subcontracts models when California is included; it becomes positive in the subcontracts model when California is excluded; it also becomes positive in the log form for both NWP and subcontracts.

Differences in the state distributions of total activity, NWP and subcontracts awards, are important in explaining some of the results listed above. For example, Louisiana, Alabama, Florida and Texas are among the first six states in total activity, but only Florida is among the first ten in subcontract awards. While these states are below average in per capita income, they exhibit substantially higher per capita growth rates in the period covered. However, the bulk of subcontract awards flows to states like California, Pennsylvania, New York and Connecticut with relatively low per capita growth rates but with higher than average per capita income.

These observations can partially account for several results listed above. First, they explain the negative relation between per capita income and per capita growth rate in relation to the dependent variable, and the shift in sign when California is deleted. Secondly, they explain the divergence between the coefficients for the growth variables in the two log cases. And, finally, they aid in explaining why the coefficients for the subcontract cases are generally more significant than in the NWP cases, since it is apparent that on the state level general or special capabilities are more relevant than changes in levels of proxies for standard of living for "explaining" aerospace activity.

The three key variables in the multiple regression analysis—private nonagricultural employment, enrollees in higher education, and percent of engineers—account for the majority of the explained variance in the models run. However, no single variable stands out as the critical measure or "predictor" of the level of NASA activity in a state.

It must be re-emphasized that the inclusion of California in the computations leads to the problem of domination by one data point over the other 48; in other words, there is nothing approaching a normal distribution in the dependent variables. The exclusion of California, however, allows the subsample of 48 states to be more truly represented, but this, in turn, deletes valuable information concerning the dominant member in the universe observed; this is the main rationale for running two different samples. The overwhelming problem, however, is that of analyzing a dynamic industry over a short period of time (2 years), on an aggregative geographic level.

## State Distribution of Research and Development Funds: Department of Defense and NASA

Let us raise the question of whether or not the state distribution of NASA prime contract awards to private for profit firms is unique, or is it similar to that of the Department of Defense, the largest Federal department in this area? The space agency obligates a significant proportion of Federal R & D funds to private firms, ranking second to the Department of Defense. The composition of obligations differs between the two agencies, not only reflecting differences between the Air Force and NASA, but also between the separate military services.[4/] Reasonably consistent data on such awards for both agencies was published by the Doddario Committee.[5/] A rank correlation between these two state distributions (N=51) resulted in a regression coefficient of 0.73 and is significant at the 0.01 level. This result is another bit of quantitative evidence that there is an

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4. For fiscal 1964, total Department of Defense prime contract awards for experimental, developmental, and research work was approximately $5.2 billion allocated in the following manner: approximately $3.4 billion Air Force, $0.9 billion Navy and $0.9 billion Army. On a comparable basis NASA awards ran about $3.4 billion.

5. See Government and Science, No. 4 Geographic Distribution of Federal Research and Development Funds, Report of the Committee on Science, Research, and Astronautics, U.S. House of Representatives, 88th Congress, 2nd Session, Serial J, Washington, D.C. 1964.

underlying capability for space/defense research and development work beneath the geographic pattern of awards.

Since the development and production of weapons and space systems is by far the largest single element of government spending, political variables are obviously reflected in their acquisition. They are apt to be of considerable concern to elected officials who want to look after the interests of the individual state and local political units they represent. Many veterans of government contracting procedures would argue that state distributions and the association between the agencies' contracts follow from this political concern.

We did not investigate this aspect, although the political influences playing in this area are well worth studying. We can, however, cite an authoritative study on the Department of Defense on this point:

> "In general, we would conclude that political considerations have not played a really major role in the choice of contractors for advanced weapons programs. Our research disclosed no instances in which firms were selected for which a non-political justification could not be made—always there were at least some long-run considerations arguing for their choice. It is reasonable to conclude from the available evidence that political influences seldom lead to decisions which are seriously uneconomic from both short-run and long-run points of view."[6]

## Summary

Section III repeatedly emphasized the technological network linking together the firms engaged in civilian space activity. These references were based on a microanalysis of the firms identified and on the significant overlap, in terms of value, of prime and subcontractors. In Section IV, the basic reference unit was the state and space activity was related to

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6. M. J. Peck and F. M. Scherer, op. cit., p. 381.

attributes of such geographic units. The hypothesis of specialized capability was not inconsistent with the results, but the same can be said about the hypothesis of generalized capability. Are the findings, then, shown in the two sections contradictory? We think not.

It seems reasonable to reach this conclusion in part from the differences seen in looking at the problem in each section. In Section III, the emphasis was on firm interrelationships with some consideration of tasks involved. Geography was not an important variable in this approach. It appeared to us, based on NASA tabulations on the overlap mentioned above, that a definite network of interrelationships was outlined. In addition, the positive correlation between the Department of Defense and NASA awards supported this conclusion.

In Section IV, the analysis was of geographic location of activity and possible associative attributes. The finer technological pattern asserted was not invalidated here. As a matter of fact, two of the most significant variables—number of physicists and astronomers, and percent of engineers—were proxies for such speciality. If the charge be leveled that these are bland correlations of space activity with those occupational classes performing such activities, the defense is that this report was to identify attributes of population or place associated with space work and not to name "cause and effect."

Turning back to Section III, we described a subset of firms important as both prime and subcontractors. A logical inference drawn from this is one of industrial concentration accompanied by geographic concentration, e.g., California. Some comparisons are in order. For example, for the aircraft industry in 1958, prior to any large impact from the space program, 58 percent of the value of shipments were accounted for by the largest four companies, and 82 percent by the largest eight companies.[7] Comparable figures for current NASA work by firms are not available, but any concentration would seemingly be a continuation of an ongoing pattern in the aerospace (aircraft) industry.

We have not answered the policy question raised much earlier on "efficiency" or "distributive" criteria for decision making. What we have indicated is our belief that there is an economic and technological rationale for what has been done. In a real sense, the above question is a value one and depends on subjective value systems not yet susceptible to rigorous rules. Different individuals and organizations optimize on different and conflicting things. Optimization on technology may be in conflict with economic efficiency; economic efficiency may conflict with other social values, such as "fair shares" of work. Yet, the spending of public funds carries with it a public trust. If geographic distribution is a societal goal of NASA awards, then there may well be a conflict between national goals and organizational space goals, a divergence between total social costs and benefits and program costs and benefits. If geographic distribution is an important consideration, then this divergence should be reflected in the agency's budget.

For an outsider, the information required to more adequately ascertain the broad patterns described herein is lacking. An agency—such as NASA—has many formal and informal information and communication devices. But it is doubtful that even insiders have the required information in appropriate form to bear on distributional and efficiency questions. Information

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7. U.S. Bureau of the Census, Statistical Abstract of the United States, 1964 (85th edition) Washington, D.C., 1964, p. 782.

collection and communication need improvement. In the next section we turn to some questions bearing on information systems.

# SECTION IV

# STATISTICAL APPENDIX

# LIST OF VARIABLES AND SOURCES

Dependent Variables:

1. Net work performed ($Y_1$) - NASA Procurement Reports and Data Tabulations, Fiscal Years 1963 and 1964.

2. Subcontracts received ($Y_2$) - Same source as above.

Independent Variables:

1. Per capita personal income ($X_1$) - Survey of Current Business, April, 1965, average for 1963-64.

2. Employees in manufacturing establishments ($X_2$) - Bureau of Labor Statistics, Employment and Earnings, May 1965, average for 1963-64.

3. Total physicists and astronomers ($X_3$) - National Science Foundation, Science Register, 1962.

4. Percent of nation's engineers ($X_4$) - Census of Population, 1960.

5. Manufacturing wages and salaries per employee ($X_5$) - Census of Manufactures, 1963, Part 3.

6. Employees in private nonagricultural establishments ($X_6$) - Bureau of Labor Statistics, Employment and Earnings, May, 1965, average for 1963-64.

7. Percent of state population living in SMSA's ($X_7$) - Census of Population, 1960.

8. Number of persons enrolled in higher education ($X_8$) - U. S. Department of Health, Education, and Welfare, Opening Enrollment in Higher Education, average for 1963-64.

9. Capital expenditures by manufacturing establishments ($X_9$) - Census of Manufactures, 1963, Part 4.

10. State expenditures ($X_{10}$) - U. S. Statistical Abstract, 1964 (1963 data).

11. Rate of growth ($X_{11}$) - Survey of Current Business, April, 1965, measured by change from 1948-63 in constant dollar aggregate personal income.

12. Rate of growth, per capita ($X_{12}$) - Same source as above, on a per capita basis.

13. Value added by manufactures ($X_{13}$) - Census of Manufactures, 1963.

Table I

Simple Regression Analysis[a/]

(intercept term in all equations is measured in millions of dollars)

Case IA: Net Work Performed, n = 49

Tests of Significance

F: degrees of freedom

1, 47

significance:

4.05 (5%)

7.21 (1%)

T: degrees of freedom

47

significance:

1.68 (5%)

2.42 (1%)

1. $Y_1 = -357 \text{ mil} + 203{,}951\ X_1$
   (124,115)

   $R^2 = 0.05$ $t = 1.64$

   $F = 2.7$ $R/S_{yx} = 7.2$

2. $Y_1 = -27.8 \text{ mil} + 425\ X_2$
   (129)

   $R^2 = 0.19$ $t = 3.29$

   $F = 10.8$ $R/S_{yx} = 7.4$

3. $Y_1 = -66.8 \text{ mil} + 435{,}805\ X_3$
   (59,702)

   $R^2 = 0.53$ $t = 7.30$

   $F = 53.3$ $R/S_{yx} = 7.9$

4. $Y_1 = -98.7 \text{ mil} + 107{,}576{,}000\ X_4$

$(15{,}203{,}000)$

$R^2 = 0.515$ $t = 7.08$

$F = 50.1$ $R/S_{yx} = 7.4$

5. $Y_1 = -491 \text{ mil} + 110{,}326\ X_5$

$(69{,}514)$

$R^2 = 0.05$ $t = 1.59$

$F = 2.5$ $R/S_{yx} = 7.2$

6. $Y_1 = -69.8 \text{ mil} + 197.1\ X_6$

$(45.2)$

$R^2 = 0.29$ $t = 4.36$

$F = 19.0$ $R/S_{yx} = 7.9$

7. $Y_1 = -113 \text{ mil} + 4{,}898{,}843\ X_7$

$(2{,}246{,}963)$

$R^2 = 0.09$ $t = 2.18$

$F = 4.75$ $R/S_{yx} = 7.2$

8. $Y_1 = -134 \text{ mil} + 2{,}496\ X_8$

$(291)$

$R^2 + 0.61$ $t = 8.59$

$F = 73.7$ $R/S_{yx} = 7.8$

10. $Y_1 = -145 \text{ mil} + 383\ X_{10}$

$(55.4)$

$R^2 = 0.50$ $t = 6.91$

$F = 47.7$ $R/S_{yx} = 8.2$

9. $Y_1 = -58.5 \text{ mil} + 791\ X_9$

$(204)$

$R^2 = 0.24$ $t = 3.88$

$F = 15.1$ $R/S_{yx} = 7.4$

11. $Y_1 = -60.6 \text{ mil} + 50{,}723{,}365 \, X_{11}$

$(37{,}864{,}194)$

$R^2 = 0.04$ $t = 1.34$

$F = 1.80$ $^R/S_{yx} = 7.5$

12. $Y_1 = 159 \text{ mil} - 21{,}222{,}463 \, X_{12}$

$(104{,}383{,}357)$

$R^2 = 0.001$ $t = -0.20$

$F = 0.04$ $^R/S_{yx} = 6.9$

13. $Y_1 = -34.9 \text{ mil} + 40.0 \, X_{13}$

$(10.9)$

$R^2 = 0.22$ $t = 3.67$

$F = 13.5$ $^R/S_{yx} = 7.4$

Case IIA: Net Work Performed, $n = 48$ (California deleted)

Tests of Significance

F: <u>degrees of freedom</u>

1, 46

<u>significance:</u>

4.05 (5%)

7.21 (1%)

T: <u>degrees of freedom</u>

46

<u>significance:</u>

1.67 (5%)

2.42 (1%)

1. $Y_1 = 2.91 \text{ mil} + 25{,}250\ X_1$
   (29,836)

   $R^2 = 0.015$ $t = 0.85$

   $F = 0.72$ $R/S_{yx} = 4.8$

2. $Y_1 = 30.1 \text{ mil} + 96.5\ X_2$
   (32.3)

   $R^2 = 0.16$ $t = 2.99$

   $F = 8.9$ $R/S_{yx} = 5.6$

3. $Y_1 = 31.8 \text{ mil} + 82{,}452\ X_3$
   (24,192)

   $R^2 = 0.20$ $t = 3.41$

   $F = 11.6$ $R/S_{yx} = 5.4$

4. $Y_1 = 23.1 \text{ mil} + 21{,}734{,}689\ X_4$
   (5,809,617)

   $R^2 = 0.23$ $t = 3.74$

   $F = 14.0$ $R/S_{yx} = 5.9$

5. $Y_1 = -11.1 \text{ mil} + 13{,}207\ X_5$

(16,674)

$R^2 = 0.01$ $t = 0.79$

$F = 0.63$ $^R/S_{yx} = 4.7$

6. $Y_1 = 19.8 \text{ mil} + 47.0\ X_6$

(11.9)

$R^2 = 0.25$ $t = 3.95$

$F = 15.6$ $^R/S_{yx} = 6.1$

7. $Y_1 = -10.6 \text{ mil} + 1{,}544{,}153\ X_7$

(507,591)

$R^2 = 0.17$ $t = 3.04$

$F = 9.25$ $^R/S_{yx} = 5.4$

8. $Y_1 = 15.3 \text{ mil} + 525\ X_8$

(134)

$R^2 = 0.25$ $t = 3.91$

$F = 15.3$ $^R/S_{yx} = 5.8$

10. $Y_1 = 8.82 \text{ mil} + 84.8\ X_{10}$

(19.8)

$R^2 = 0.29$ $t = 4.29$

$F = 18.4$ $^R/S_{yx} = 5.6$

9. $Y_1 = 29.2 \text{ mil} + 154\ X_9$

(55)

$R^2 = 0.15$ $t = 2.81$

$F = 7.9$ $^R/S_{yx} = 5.5$

11. $Y_1 = 26.1 \text{ mil} + 10{,}088{,}905\ X_{11}$

$(8{,}870{,}409)$

$R^2 = 0.03$ $t = 1.14$

$F = 1.29$ $^R/S_{yx} = 4.9$

12. $Y_1 = -10.7 \text{ mil} + 39{,}038{,}403\ X_{12}$

$(23{,}440{,}787)$

$R^2 = 0.06$ $t = 1.67$

$F = 2.77$ $^R/S_{yx} = 4.6$

13. $Y_1 = 31.7 \text{ mil} + 8.33\ X_{13}$

$(2.85)$

$R^2 = 0.16$ $t = 2.92$

$F = 8.51$ $^R/S_{yx} = 5.6$

Case IIIA: Net Work Performed, $n = 46$
reduced to natural logarithms

Tests of Significance

F: degrees of freedom

1, 44

significance

4.06 (5%)

7.24 (1%)

T: degrees of freedom:

44

significance:

1.68 (5%)

2.42 (1%)

1. $Y_1 = 3.72 + 0.002\ X_1$
$$(0.0008)$$
$R^2 = 0.15$ $t = 2.80$
$F = 7.82$ $R/S_{yx} = 4.3$

2. $Y_1 = 7.84 + 0.003\ X_2$
$$(0.0009)$$
$R^2 = 0.25$ $t = 3.80$
$F = 14.5$ $R/S_{yx} = 4.0$

3. $Y_1 = 7.95 + 0.003\ X_3$
$$(0.0007)$$
$R^2 = 0.28$ $t = 4.17$
$F = 17.4$ $R/S_{yx} = 4.2$

4. $Y_1 = 7.62 + 0.75\ X_4$
$$(0.16)$$
$R^2 = 0.34$ $t = 4.75$
$F = 22.5$ $R/S_{yx} = 4.2$

5. $Y_1 = 2.50 + 0.001\ X_5$
$$(0.0005)$$
$R^2 = 0.13$ $t = 2.58$
$F = 6.65$ $R/s_{yx} = 4.1$

6. $Y_1 = 7.62 + 0.0015\ X_6$
$$(0.0003)$$
$R^2 = 0.31$ $t = 4.46$
$F = 19.9$ $R/s_{yx} = 4.1$

7. $Y_1 = 5.74 + 0.07\ X_7$
$$(0.013)$$
$R^2 = 0.39$ $t = 5.27$
$F = 27.8$ $R/s_{yx} = 4.2$

8. $Y_1 = 7.46 + 0.017\ X_8$
$$(0.004)$$
$R^2 = 0.32$ $t = 4.51$
$F = 20.3$ $R/s_{yx} = 4.0$

10. $Y_1 = 7.41 + 0.0025\ X_{10}$
$$(0.0006)$$
$R^2 = 0.30$ $t = 4.31$
$F = 18.5$ $R/s_{yx} = 3.7$

9. $Y_1 = 7.73 + 0.006\ X_9$
$$(0.0015)$$
$R^2 = 0.25$ $t = 3.86$
$F = 14.9$ $R/s_{yx} = 3.9$

11. $Y_1 = 7.69 + 0.37\ X_{11}$
$$(0.26)$$
$R^2 = 0.04$ $t = 1.40$
$F = 1.96$ $^R/S_{yx} = 3.5$

12. $Y_1 = 6.56 + 1.29\ X_{12}$
$$(0.70)$$
$R^2 = 0.07$ $t = 1.84$
$F = 3.37$ $^R/S_{yx} = 3.5$

13. $Y_1 = 7.86 + 0.0003\ X_{13}$
$$(0.00008)$$
$R^2 = 0.26$ $t = 3.90$
$F = 15.2$ $^R/S_{yx} = 4.0$

Case IB: Subcontracts Received, n = 49

Tests of Significance

F: <u>degrees of freedom</u>

1, 47

<u>significance:</u>

4.05 (5%)

7.21 (1%)

T: <u>degrees of freedom</u>

47

<u>significance:</u>

1.68 (5%)

2.42 (1%)

1. $Y_2 = -102 \text{ mil} + \underset{(24{,}809)}{54{,}962}\, X_1$

$R^2 = 0.09$ $t = 2.22$

$F = 4.91$ $R/S_{yx} = 7.4$

2. $Y_2 = -9.51 \text{ mil} + \underset{(25.1)}{104}\, X_2$

$R^2 = 0.27$ $t = 4.14$

$F = 17.1$ $R/S_{yx} = 7.5$

3. $Y_2 = -14.8 \text{ mil} + \underset{(10{,}920)}{96{,}495}\, X_3$

$R^2 = 0.62$ $t = 8.84$

$F = 78.1$ $R/S_{yx} = 7.9$

4. $Y_2 = -21.3 \text{ mil} + \underset{(2{,}848{,}141)}{23{,}557{,}841}\, X_4$

$R^2 = 0.59$ $t = 8.27$

$F = 68.4$ $R/S_{yx} = 7.2$

5. $Y_2 = -12.2 \text{ mil} + 26{,}815\ X_5$

$(14{,}041)$

$R^2 = 0.07$ $t = 1.91$

$F = 3.65$ $R/S_{yx} = 7.2$

6. $Y_2 = -16.8 \text{ mil} + 45.1\ X_6$

$(8.7)$

$R^2 = 0.36$ $t = 5.16$

$F = 26.6$ $R/S_{yx} = 7.9$

7. $Y_2 = -29.0 \text{ mil} + 1{,}168{,}536\ X_7$

$(450{,}481)$

$R^2 = 0.13$ $t = 2.59$

$F = 6.73$ $R/S_{yx} = 7.3$

8. $Y_2 = -27.8 \text{ mil} + 534\ X_8$

$(54.6)$

$R^2 = 0.67$ $t = 9.78$

$F = 95.7$ $R/S_{yx} = 7.5$

10. $Y_2 = -30.5 \text{ mil} + 82.3\ X_{10}$

$(10.7)$

$R^2 = 0.56$ $t = 7.70$

$F = 59.3$ $R/S_{yx} = 7.9$

9. $Y_2 = -14.2 \text{ mil} + 180\ X_9$

$(39.9)$

$R^2 = 0.30$ $t = 4.53$

$F = 20.5$ $R/S_{yx} = 7.5$

11. $Y_2 = -3.44 \text{ mil} + 8{,}436{,}009\ X_{11}$

$(7{,}780{,}664)$

$R^2 = 0.02$ $t = 1.08$

$F = 1.18$ $R/S_{yx} = 7.3$

12. $Y_2 = 51.4 \text{ mil} - 13{,}414{,}769\ X_{12}$

$(21{,}242{,}315)$

$R^2 = 0.008$ $\quad t = -0.63$

$F = 0.40$ $\quad {}^R/S_{yx} = 6.9$

13. $Y_2 = -9.98 \text{ mil} + 9.45\ X_{13}$

$(2.12)$

$R^2 = 0.30$ $\quad t = 4.46$

$F = 19.9$ $\quad {}^R/S_{yx} = 7.5$

Case IIB: Subcontracts Received, $n = 48$ (California deleted)

Tests of Significance

F: degrees of freedom

1, 46

significance:

4.05 (5%)

7.21 (1%)

T: degrees of freedom

46

significance:

1.67 (5%)

2.42 (1%)

1. $Y_2 = -31.1 \text{ mil} + 19{,}747\ X_1$

   (7,279)

   $R^2 = 0.14$ $t = 2.71$

   $F = 7.36$ $R/S_{yx} = 5.2$

2. $Y_2 = 1.64 \text{ mil} + 40.6\ X_2$

   (7.0)

   $R^2 = 0.42$ $t = 5.79$

   $F = 33.6$ $R/S_{yx} = 4.7$

3. $Y_2 = 2.97 \text{ mil} + 32{,}942\ X_3$

   (5,123)

   $R^2 = 0.47$ $t = 6.43$

   $F = 41.4$ $R/S_{yx} = 5.0$

4. $Y_2 = 1.09 \text{ mil} + 7{,}778{,}994\ X_4$

   (1,295,064)

   $R^2 = 0.44$ $t = 6.01$

   $F = 36.1$ $R/S_{yx} = 4.6$

5. $Y_2 = -26.6 \text{ mil} + 7{,}526\ X_5$
$(4{,}234)$
$R^2 = 0.06$ $t = 1.78$
$F = 3.16$ $R/S_{yx} = 4.7$

6. $Y_2 = 0.31 \text{ mil} + 16.4\ X_6$
$(2.7)$
$R^2 = 0.45$ $t = 6.14$
$F = 37.7$ $R/S_{yx} = 4.7$

7. $Y_2 = -8.71 \text{ mil} + 504{,}385\ X_7$
$(124{,}535)$
$R^2 = 0.26$ $t = 4.05$
$F = 16.4$ $R/S_{yx} = 4.9$

8. $Y_2 = -0.55 \text{ mil} + 175\ X_8$
$(31.1)$
$R^2 = 0.41$ $t = 5.62$
$F = 31.6$ $R/S_{yx} = 4.8$

10. $Y_2 = -1.41 \text{ mil} + 26.1\ X_{10}$
$(4.7)$
$R^2 = 0.40$ $t = 5.53$
$F = 30.6$ $R/S_{yx} = 4.3$

9. $Y_2 = 2.75 \text{ mil} + 57.8\ X_9$
$(13.0)$
$R^2 = 0.30$ $t = 4.45$
$F = 19.8$ $R/S_{yx} = 4.1$

11. $Y_2 = 14.1 \text{ mil} + 234{,}437\ X_{11}$
$(2{,}344{,}869)$
$R^2 = 0.0002$ $t = 0.10$
$F = 0.01$ $R/S_{yx} = 4.3$

12. $Y_2 = 17.5 \text{ mil} - 1{,}387{,}106\ X_{12}$
$(6{,}290{,}077)$

$R^2 = 0.001$ $t = -0.22$

$F = 0.05$ $^R/S_{yx} = 4.2$

13. $Y_2 = 2.82 \text{ mil} + 3.36\ X_{13}$
$(0.64)$

$R^2 = 0.37$ $t = 5.24$

$F = 27.4$ $^R/S_{yx} = 4.5$

Case IIIB: Subcontracts Received, n = 44
reduced to natural logarithms

Tests of Significance

F: degrees of freedom

1, 42

significance:

4.07 (5%)

7.27 (1%)

T: degrees of freedom

42

significance:

1.68 (5%)

2.42 (1%)

1. $Y_2 = 3.17 + 0.002\ X_1$
$(0.00067)$

$R^2 = 0.18$ $t = 3.03$

$F = 9.15$ $R/S_{yx} = 4.2$

2. $Y_2 = 6.76 + 0.003\ X_2$
$(0.0007)$

$R^2 = 0.32$ $t = 4.43$

$F = 19.7$ $R/S_{yx} = 4.0$

3. $Y_2 = 7.02 + 0.002\ X_3$
$(0.0006)$

$R^2 = 0.27$ $t = 3.93$

$F = 15.5$ $R/S_{yx} = 4.2$

4. $Y_2 = 6.61 + 0.68\ X_4$
$(0.13)$

$R^2 = 0.40$ $t = 5.26$

$F = 27.7$ $R/S_{yx} = 4.0$

5. $Y_2 = 1.87 + 0.001\ X_5$
$(0.0004)$

$R^2 = 0.17$ $t = 2.91$
$F = 8.47$ $^R/S_{yx} = 4.1$

6. $Y_2 = 6.63 + 0.0013\ X_6$
$(0.0003)$

$R^2 = 0.36$ $t = 4.84$
$F = 23.5$ $^R/S_{yx} = 4.0$

7. $Y_2 = 4.46 + 0.07\ X_7$
$(0.01)$

$R^2 = 0.54$ $t = 6.97$
$F = 48.6$ $^R/S_{yx} = 4.5$

8. $Y_2 = 6.51 + 0.015\ X_8$
$(0.003)$

$R^2 = 0.35$ $t = 4.74$
$F = 22.4$ $^R/S_{yx} = 4.0$

10. $Y_2 = 6.45 + 0.002\ X_{10}$
$(0.0005)$

$R^2 = 0.33$ $t = 4.57$
$F = 20.9$ $^R/S_{yx} = 3.9$

9. $Y_2 = 6.68 + 0.005\ X_9$
$(0.001)$

$R^2 = 0.31$ $t = 4.38$
$F = 19.2$ $^R/S_{yx} = 3.9$

11. $Y_2 = 6.73 + 0.32\ X_{11}$

$(0.22)$

$R^2 = 0.05$ $t = 1.46$

$F = 2.14$ $^R/S_{yx} = 3.7$

12. $Y_2 = 7.41 + 0.26\ X_{12}$

$(0.66)$

$R^2 = 0.004$ $t = 0.39$

$F = 0.16$ $^R/S_{yx} = 3.6$

13. $Y_2 = 6.78 + 0.0003\ X_{13}$

$(0.00006)$

$R^2 = 0.33$ $t = 4.57$

$F = 20.8$ $^R/S_{yx} = 4.0$

---

a. Equation and variable number correspond to those given in chart at beginning of appendix.

Table II

Combinations of Independent Variables—Net Work Performed

Model I

Variables Selected:

$Y_1$ - Net Work Performed (000)

$X_1$ - Per Capita Income

$X_6$ - Private, Nonagricultural Employment (000)

$X_{11}$ - Growth Rate

$X_{12}$ - Per Capita Growth Rate

A. With California -

$$Y_1 = 25{,}960{,}000 - \underset{(124.0)}{56.5X_1} + \underset{(49.1)}{201.1X_6} + \underset{(41{,}992)}{79{,}490X_{11}}$$

$$- \underset{(29{,}487)}{35{,}675X_{12}}$$

| | | Significant at .01 | Significant at .05 |
|---|---|---|---|
| $R^2 = 0.34;$ | $F = 5.72$ | Yes | Yes |
| | $T_1 = -0.46$ | No | No |
| | $T_6 = 4.10$ | Yes | Yes |
| | $T_{11} = 1.89$ | No | Yes |
| | $T_{12} = -1.21$ | No | No |

B. Without California -

$$Y_1 = -27{,}923{,}000 - \underset{(29.2)}{12.2X_1} + \underset{(12.8)}{49.4X_6} + \underset{(10{,}220)}{5{,}981X_{11}}$$

$$+ \underset{(26{,}982)}{28{,}507X_{12}}$$

| | | | Significant at .01 | Significant at .05 |
|---|---|---|---|---|
| $R^2 = 0.32;$ | $F$ | $= 4.98$ | Yes | Yes |
| | $T_1$ | $= -0.42$ | No | No |
| | $T_6$ | $= 3.87$ | Yes | Yes |
| | $T_{11}$ | $= 0.59$ | No | No |
| | $T_{12}$ | $= 1.06$ | No | No |

C. Without California, $Y_1$ in natural logs.

$$\underset{}{\mathrm{Log}_e Y_1} = 1.38 + \underset{(0.00076)}{0.0015X_1} + \underset{(0.0003)}{0.001X_6} + \underset{(0.27)}{0.06X_{11}}$$

$$+ \underset{(0.72)}{1.45X_{12}}$$

| | | | Significant at .01 | Significant at .05 |
|---|---|---|---|---|
| $R^2 = 0.46;$ | $F$ | $= 8.64$ | Yes | Yes |
| | $T_1$ | $= 1.95$ | No | Yes |
| | $T_6$ | $= 3.91$ | Yes | Yes |
| | $T_{11}$ | $= 0.23$ | No | No |
| | $T_{12}$ | $= 2.03$ | No | Yes |

Model II

Variables Selected:

$Y$ - Net Work Performed (000)

$X_1$ - Per Capita Income

$X_8$ - Number of Enrollees in Higher Education (000)

$X_{11}$ - Growth Rate

$X_{12}$ - Per Capita Growth Rate

A. With California -

$$Y_1 = 66{,}831{,}000 - \underset{(89.0)}{114.7X_1} + \underset{(309.8)}{2{,}576X_8} + \underset{(30{,}688)}{60{,}007X_{11}}$$

$$- \underset{(82{,}047)}{83{,}462X_{12}}$$

| | | | Significant at .01 | Significant at .05 |
|---|---|---|---|---|
| $R^2 = 0.65$; | $F$ = | 20.1 | Yes | Yes |
| | $T_1$ = | -1.29 | No | No |
| | $T_8$ = | 8.32 | Yes | Yes |
| | $T_{11}$ = | 1.96 | No | Yes |
| | $T_{12}$ = | -1.02 | No | No |

B. Without California -

$$Y_1 = -38{,}793{,}000 - \underset{(29.0)}{10.7X_1} + \underset{(143.1)}{553.5X_8} + \underset{(10{,}215)}{5{,}684X_{11}}$$

$$+ \underset{(26{,}926)}{30{,}126X_{12}}$$

| | | | Significant at .01 | Significant at .05 |
|---|---|---|---|---|
| $R^2 = 0.32$; | $F$ = | 4.98 | Yes | Yes |
| | $T_1$ = | -0.37 | No | No |
| | $T_8$ = | 3.87 | Yes | Yes |
| | $T_{11}$ = | 0.57 | No | No |
| | $T_{12}$ = | 1.12 | No | No |

C. Without California, $Y_1$ in natural logs.

$$\text{Log}_e Y_1 = 1.17 + \underset{(0.00075)}{0.0015X_1} + \underset{(0.004)}{0.015X_8} + \underset{(0.26)}{0.06X_{11}}$$

$$+ \underset{(0.71)}{1.48X_{12}}$$

| | | | Significant at .01 | Significant at .05 |
|---|---|---|---|---|
| $R^2 = 0.47$; | $F$ = | 9.04 | Yes | Yes |
| | $T_1$ = | 2.00 | No | Yes |
| | $T_8$ = | 4.06 | Yes | Yes |
| | $T_{11}$ = | 0.24 | No | No |
| | $T_{12}$ = | 2.10 | No | Yes |

Model III

Variables Selected:

Y - Net Work Performed (000)

$X_1$ - Per Capita Income

$X_4$ - Percent of Nation's Engineers

$X_{11}$ - Growth Rate

$X_{12}$ - Per Capita Growth Rate

A. With California -

$$Y = 200{,}179{,}000 - \underset{(102.5)}{153.4X_1} + \underset{(16{,}737)}{114{,}983X_4} + \underset{(34{,}171)}{64{,}744X_{11}} - \underset{(91{,}318)}{100{,}450X_{12}}$$

| | | | Significant at .01 | Significant at .05 |
|---|---|---|---|---|
| $R^2 = 0.56$; | $F$ = | 14.1 | Yes | Yes |
| | $T_1$ = | -1.50 | No | No |
| | $T_4$ = | 6.87 | Yes | Yes |
| | $T_{11}$ = | 1.89 | No | Yes |
| | $T_{12}$ = | -1.10 | No | No |

B. Without California -

$$Y_1 = -9{,}798{,}000 - \underset{(30.4)}{19.4X_1} + \underset{(6{,}417)}{23{,}754X_4} + \underset{(10{,}308)}{5{,}226X_{11}} + \underset{(27{,}234)}{30{,}220X_{12}}$$

| | | | Significant at .01 | Significant at .05 |
|---|---|---|---|---|
| $R^2 = 0.30$; | $F$ = | 4.64 | Yes | Yes |
| | $T_1$ = | -0.64 | No | No |
| | $T_4$ = | 3.70 | Yes | Yes |
| | $T_{11}$ = | 0.51 | No | No |
| | $T_{12}$ = | 1.11 | No | No |

C. Without California, $Y_1$ in natural logs.

$$\text{Log}_e Y_1 = 1.96 + \underset{(0.0008)}{0.0012X_1} + \underset{(0.16)}{0.67X_4} + \underset{(0.26)}{0.05X_{11}} + \underset{(0.71)}{1.48X_{12}}$$

| | | | Significant at .01 | Significant at .05 |
|---|---|---|---|---|
| $R^2 = 0.47$; | $F$ = | 9.01 | Yes | Yes |
| | $T_1$ = | 1.56 | No | No |
| | $T_2$ = | 4.05 | Yes | Yes |
| | $T_3$ = | 0.20 | No | No |
| | $T_4$ = | 2.09 | No | Yes |

Table III

Combinations of Independent Variables—Subcontracts

Model I

Variables Selected:

$Y_2$ - Subcontracts Received (000)

$X_1$ - Per Capita Income

$X_6$ - Private, Nonagricultural Employment (000)

$X_{11}$ - Growth Rate

$X_{12}$ - Per Capita Growth Rate

A. With California -

$$Y_2 = -4{,}760{,}000 - \underset{(23.9)}{1.0X_1} + \underset{(9.5)}{44.1X_6} + \underset{(8{,}084)}{14{,}861X_{11}} - \underset{(21{,}564)}{33{,}451X_{12}}$$

| | | Significant at .01 | Significant at .05 |
|---|---|---|---|
| $R^2 = 0.42$; | $F = 7.83$ | Yes | Yes |
| | $T_1 = -0.04$ | No | No |
| | $T_6 = 4.67$ | Yes | Yes |
| | $T_{11} = 1.84$ | No | Yes |
| | $T_{12} = -1.55$ | No | No |

B. Without California -

$$Y_2 = -14{,}997{,}000 + \underset{(6.7)}{7.4X_1} + \underset{(2.9)}{15.2X_6} + \underset{(2{,}337)}{876X_{11}} - \underset{(6{,}170)}{2{,}215X_{12}}$$

| | | Significant at .01 | Significant at .05 |
|---|---|---|---|
| $R^2 = 0.47$; | $F = 9.70$ | Yes | Yes |
| | $T_1 = 1.12$ | No | No |
| | $T_6 = 5.21$ | Yes | Yes |
| | $T_{11} = 0.37$ | No | No |
| | $T_{12} = -0.36$ | No | No |

C. Without California, $Y_2$ in natural logs.

$$\text{Log}_e Y_2 = 3.20 + \underset{(0.0006)}{0.0009X_1} + \underset{(0.0003)}{0.001X_6} + \underset{(0.22)}{0.37X_{11}} + \underset{(0.64)}{0.015X_{12}}$$

| | | | | Significant at .01 | Significant at .05 |
|---|---|---|---|---|---|
| $R^2 = 0.47$; | F | = | 8.68 | Yes | Yes |
| | $T_1$ | = | 1.45 | No | No |
| | $T_6$ | = | 4.43 | Yes | Yes |
| | $T_{11}$ | = | 1.65 | No | No |
| | $T_{12}$ | = | 0.023 | No | No |

Model II

Variables Selected:

$Y_2$ - Subcontracts Received (000)

$X_1$ - Per Capita Income

$X_8$ - Number Enrolled in Higher Education (000)

$X_{11}$ - Growth Rate

$X_{12}$ - Per Capita Growth Rate

A. With California -

$$Y_2 = 190{,}500 - \underset{(16.9)}{10.5X_1} + \underset{(58.8)}{532.3X_8} + \underset{(5{,}526)}{10{,}663X_{11}} - \underset{(15{,}575)}{22{,}355X_{12}}$$

| | | | | Significant at .01 | Significant at .05 |
|---|---|---|---|---|---|
| $R^2 = 0.69$; | F | = | 25.0 | Yes | Yes |
| | $T_1$ | = | -0.62 | No | No |
| | $T_8$ | = | 9.05 | Yes | Yes |
| | $T_{11}$ | = | 1.83 | No | Yes |
| | $T_{12}$ | = | -1.44 | No | No |

B. Without California -

$$Y_2 = -19{,}227{,}000 + \underset{(6.9)}{8.7X_1} + \underset{(33.9)}{160.4X_8} + \underset{(2{,}420)}{710X_{11}} - \underset{(6{,}378)}{1{,}473X_{12}}$$

| | | | | Significant at .01 | .05 |
|---|---|---|---|---|---|
| $R^2 = 0.44$; | F | = | 8.31 | Yes | Yes |
| | $T_1$ | = | 1.26 | No | No |
| | $T_8$ | = | 4.73 | Yes | Yes |
| | $T_{11}$ | = | 0.29 | No | No |
| | $T_{12}$ | = | -0.23 | No | No |

C. Without California, $Y_2$ in natural logs.

$$\text{Log}_e Y_2 = 2.88 + \underset{(0.0006)}{0.001X_1} + \underset{(0.003)}{0.014X_8} + \underset{(0.23)}{0.36X_{11}} + \underset{(0.64)}{0.074X_{12}}$$

| | | | | Significant at .01 | .05 |
|---|---|---|---|---|---|
| $R^2 = 0.47$; | F | = | 8.54 | Yes | Yes |
| | $T_1$ | = | 1.52 | No | No |
| | $T_8$ | = | 4.38 | Yes | Yes |
| | $T_{11}$ | = | 1.62 | No | No |
| | $T_{12}$ | = | 0.12 | No | No |

Model III

Variables Selected:

Y - Subcontracts Received (000)

$X_1$ - Per Capita Income

$X_4$ - Percent of Nation's Engineers

$X_{11}$ - Growth Rate

$X_{12}$ - Per Capita Growth Rate

A. With California -

$$Y_2 = 29{,}322{,}000 - \underset{(19.4)}{19.5X_1} + \underset{(3{,}165)}{24{,}163X_4} + \underset{(6{,}462)}{11{,}638X_{11}} - \underset{(17{,}269)}{25{,}832X_{12}}$$

| | | | | Significant at .01 | Significant at .05 |
|---|---|---|---|---|---|
| $R^2 = 0.62$; | $F$ | = | 18.3 | Yes | Yes |
| | $T_1$ | = | -1.01 | No | No |
| | $T_4$ | = | 7.63 | Yes | Yes |
| | $T_{11}$ | = | 1.80 | No | Yes |
| | $T_{12}$ | = | 1.50 | No | No |

B. Without California -

$$Y_2 = -9{,}492{,}000 + \underset{(7.0)}{5.3X_1} + \underset{(1{,}483)}{7{,}296X_4} + \underset{(2{,}382)}{636X_{11}} - \underset{(6{,}294)}{1{,}673X_{12}}$$

| | | | | Significant at .01 | Significant at .05 |
|---|---|---|---|---|---|
| $R^2 = 0.45$; | $F$ | = | 8.83 | Yes | Yes |
| | $T_1$ | = | 0.75 | No | No |
| | $T_4$ | = | 4.92 | Yes | Yes |
| | $T_{11}$ | = | 0.27 | No | No |
| | $T_{12}$ | = | -0.27 | No | No |

C. Without California, $Y_2$ in natural logs

$$\text{Log}_e Y = 3.75 + \underset{(0.00065)}{0.0007X_1} + \underset{(0.14)}{0.64X_4} + \underset{(0.22)}{0.36X_{11}} + \underset{(0.63)}{0.05X_{12}}$$

| | | | | Significant at .01 | Significant at .05 |
|---|---|---|---|---|---|
| $R^2 = 0.49$; | $F$ | = | 9.25 | Yes | Yes |
| | $T_1$ | = | 1.02 | No | No |
| | $T_4$ | = | 4.63 | Yes | Yes |
| | $T_{11}$ | = | 1.64 | No | Yes |
| | $T_{12}$ | = | 0.08 | No | No |

## V. SOME CONSIDERATIONS ON THE PRELIMINARY DESIGN OF AN ECONOMIC INFORMATION SYSTEM

"The human brain also accepts inputs of information, combines it with information stored somehow within and returns outputs of information to its environment. Social institutions--such as the legislative, the law, science, education, business organizations and the communication system--receive, process and put out information in much the same way. Accordingly, in common with the computer, the human brain and social institutions may be regarded as information-processing systems, at least with respect to some critical functions." 1/

The National Aeronautics and Space Administration, like any other large scale public or private organization, may, in the context of the above quotation, be viewed as an information-processing system with respect to space exploration and the acquisition of space systems. NASA, with its internal organizations, its headquarters, and its field centers and offices, is composed of subsystems linked together through an information network. The information transmitted has its formal aspects in the innumerable reports and accounts collected and processed; its informal aspects in the humans who observe, interpret, discuss and pass on the formal data as well as messages received by word of mouth. Many bits of economic information are passed along, some of which are relevant to questions of regional impacts. With few exceptions, such economic and social information are by-products of management and fiduciary control systems. They are neither integrated into an information system for analyzing regional implications, nor are they cast within a conceptual framework that would permit such studies.

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1. John McCarthy, "Information," Scientific American, Vol. 215, No. 3 (September, 1966) p. 65.

The reason for such lack of integration is a simple one; NASA as an information processing system has not been concerned with the question of economic impacts. There has been no real overt load on the information network for other than simple tabulations of existing data. We say overt, since NASA top management has surely probed for more intensive information.

Following Hearle and Mason, we may classify an information system into five components, elements, or stages.[2] These are concerned with data input, storage, processing, output and communication. That is, an information system is the equipment, procedures, and operating personnel assembled for collecting, transmitting, storing, processing, and outputting information. It is not an end in itself, but a tool to support the functions of the user organization. The communication element of the information system is the one that transmits data to the user. This element goes beyond the hardware devices, such as cathode ray tubes. The communication stage is the one which places data in the form most meaningful to the user.[3] The key to the design of the information system stems from the communication stage to the user. For NASA, then, the design of the basic economic information for regional impact waits upon a demand from the user (top management) and a conceptual framework for utilizing such data.

Space agency management has long been aware that the agency may affect everyday terrestrial life in various ways; it has explored

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2. E. F. R. Hearle and R. J. Mason, A Data Processing System for State and Local Government, (Englewood Cliffs: Prentice Hall, 1963).

3. R. A. Siegel, A Program Approach to Information Systems, a paper delivered to the Fourth Annual Conference on Urban Planning Information Systems and Programs, Berkeley, California (August 19, 1966).

some of these ways through its support of university based regional research, its Brookings Institution Study,[4] its sponsorship of various conferences on the nonspace implications of its activities, and its technology utilization program. But more than NASA backing is required for such continuing research.

Recently, Joseph M. Goldsen called for a joint governmental and private space systems contractor funding of an institute for the study of the impact of space oriented technology and exploration on society.[5] The space agency, as the predominant public organization in space activity, is the ultimate source of much-needed information, such as appropriate data for regional analyses. It must either generate the information or permit its generation by its suppliers.

## Some NASA-Generated Data of Current and Potential Use for Regional Analysis

UCLA's main concern in undertaking this study was with the subcontractor data. We did not plan to investigate or evaluate the numerous reporting forms used by NASA or the economic data generated by the agency. As the study developed, however, some investigation of other data sources was necessary. The following samples of principal NASA data sources for measuring economic impacts resulted from

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4. See "Proposed Studies on the Implications of Peaceful Space Activities for Human Affairs," prepared for the National Aeronautics and Space Administration by the Brookings Institution, House of Representatives, 87th Congress, 1st Session, Report No. 242, U.S. Government Printing Office, Washington, D.C. (1961).

5. Joseph M. Goldsen, "Research on Social Consequences of Space Activities," (P-3220), The RAND Corporation, Santa Monica, California, (August 1965).

discussions with NASA headquarters personnel and those of our own study.

1. Individual Procurement Action Report (Form 507)
2. Subcontractor Awards (Form 667)
3. Contractor Financial Management Report (Form 533)
4. Accounting and Personnel Reports for NASA Centers and Headquarters
5. Plant-wide Economic Report (CEIS)
6. Program Operating Plans
7. Budget History

<u>Individual Procurement Action Report (507)</u>

This basic report is prepared by the field procurement offices at the time of each contract award for all prime contracts and subsequently for contract modifications. For economic analyses the following data are useful:

1. prime contract number and contract modification number
2. contract completion date
3. contractor name and address and plant of performance
4. labor surplus area designation
5. extent of available competition in course of contract negotiation.

<u>Subcontractor Awards (667)</u>

See Section II, this report.

<u>Contractor Financial Management Report (533)</u>

Form 533 is submitted monthly by prime contractors to the contracting offices for contracts of $500,000 or more extending for one year or longer; it is also submitted for contracts between $25,000 and

$500,000 let by MSFC and Headquarters. (Nonprofit research contracts and grants are reported under Form 1030.) The primary purpose of Form 533 is to provide information on accrued and projected costs for project control; evaluation of contractor performance; cost-based budget formulation; and a common language for communicating with contractors. The contract work elements used for reporting purposes correspond generally with the PERT network elements where applicable.

Of outstanding potential value here are: (1) actual and projected accrued costs by prime contractors; (2) actual and projected accrued costs of first-tier subcontractors. (The subcontractors are not separately identified.) Form 533 was extensively evaluated by a NASA committee in 1965.

## Personnel Costs and Manpower Utilization Report

This report is compiled monthly by field installations and submitted on punched cards to the Financial Management Division in NASA headquarters. Included are data on man-hours applied by unique project code and system and subsystem code where applicable. Regular time and overtime are reported separately and total man-hours for scientists and engineers are also shown separately. Current month accrued costs for manpower are also reported in the same detail.

## Plant-Wide Economic Report (CEIS)

Cost and Economic Information System (CEIS) is an interesting experiment in two ways. First, it is especially designed to provide information on contractor costs and manpower utilization for the primary purpose of measuring the economic impact of procurement contracts; and, secondly, it was run in conjunction with the Department of Defense.

There are tremendous advantages to be gained from this joint use of the same schedule. The report has been used on a pilot test basis (for the period July 1 to December 31, 1964) by DOD and NASA and is being considered as a semi-annual report to cover all large contractor reports.

The report includes the number of people currently employed on DOD work, on NASA work, and on all other work in the plant with a projection for two and one-half years ahead in the same detail. Separate detail is provided for total direct and indirect onsite employees; separate detail is also shown for scientists and engineers.

For NASA work only, costs incurred in the current period are reported with detail shown for the costs of subcontracting, materials and purchased products, services, and all other. Also included are certain details on plant floor space used currently and as projected for 12 months.

CEIS as carried out for the first trial run did not provide a basis for going beyond covered plants to the ultimate industries and geographic areas in which work is also performed. Consequently, measures of economic impact are limited to prime contractors and their place of performance. The projected employment data is of limited use since it covers only work already covered by a contract.

Program Operating Plans

These plans include projections of total costs and manpower requirements for firmed-up programs extending to 1970 and beyond. Little information is available for possible future programs under active consideration.

Budget histories are self-explanatory.

Resume of NASA Data Collection

The small sample of information sources described above suggests two weaknesses: first, fragmentation, since there is no systematic approach to the collection and integration of information for economic, especially regional, analysis; second, and a corollary of the first, fragmentation of responsibility for collecting and processing the information. Such fragmentation raises doubts on consistency and adequate quality of the data.

For an outsider this fragmentation and lack of a formal integrating system raises some perplexing questions. It is evident that NASA collects a tremendous amount of information that could bear on socio-economic effects of its activities. Yet, given the lack of systematic integration and lack of a conceptual framework, one wonders what top management obtains as it probes the system for answers to possible economic structural results of changes in old programs or possibilities for new ones.

There is often an interaction between formal and informal data systems. How does the detailed, specific, and risk knowledge of people working on programs within NASA interact with the report forms used in interpreting the data? This personal touch also has its drawbacks. To some extent it is subjective and dependent on particular individuals who, for some reason, may leave the agency. Information is power. In large public or private bureaucracies there is the tendency for "black book" operations, i.e., the use of private information and rivalry between computer rooms centering about "ownership" of data. What often emerges are monopolies with property rights in the data collected and processed. Such tendencies, if present, affect the organization through the information links connecting the organizational subsystems. Another perplexing question, again relating to a lack of system, is the data base and means for projecting future impacts, called for by the Ackley Committee.[6]

> "In developing a program of acquiring more and better information, certain considerations should be borne in mind. First, evaluation of the effects on income and employment requires detailed knowledge of actual and potential changes not only in the total amount but also in the composition of defense spending.
>
> Second, accurate information about the direct impacts on specific industries, communities, and employees must be supplemented by reliable techniques for projecting the full effects on the rest of the economy.
>
> Third, these effects must relate not only to current but also to planned programs. To be sure, planned military programs are subject to change; production sites cannot be identified before contractors are selected; and national security may preclude public disclosure (for example, of the Five Year Force Structure and Financial Program of the Department of Defense). Yet the fact remains that timely analysis and wise choice of policies are heavily dependent on the availability of timely information—to Government agencies as well as to affected communities and plants."

NASA is represented on the Ackley Committee, and what is quoted above about DOD holds for it as well. With all the uncertainties about past Apollo programs, structural impact problems similar to those that might occur with changes in defense budgets will at least be in public discussions. NASA's inclusion on the Ackley Committee is an indication that it is bracketed with DOD in the public's thinking.

The reference to the Five Year Force Structure and Financial Program above is apropos, since these structures now have counterparts

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6. Report of the Committee on the Economic Impact of Defense and Disarmament, U.S. Government Printing Office, (July 1965), pp. 57-58.

in nondefense agencies in the planning-programming-budgeting system (Program Budgeting). This process can provide a conceptual framework and an integrating device for the analysis of current and projected NASA space programs.

## The Program-Budgeting Framework

Programming-budgeting was established as a requirement for most Federal agencies (including NASA) and as an option for others by the Presidential directive of August 25, 1965. Consequently it has been in operation over a year. However, it will take several years to integrate it into the information systems and organizational structure of the covered agencies. The operations, meaning, and use is well forged over time and will differ between agencies.

If fully carried out, program budgeting will permit agency management to attain the following objectives more effectively and systematically:

1. Provide top management with more concrete and specific data on which to base decisions.

2. Define more specifically the objectives of agency program.

3. Provide for a more systematic analysis of alternative courses of action for a comparison of the benefits (effectiveness) and costs of alternate choices.

4. Produce a full, continuing cost rather than a partial cost estimate of a program or a change in program.

This is a tool for financial management. It is also analogous to a command and control system that moves towards rationalizing the allocation of scarce resources—the command aspect—and controlling them through periodic reports and achievement measures. The information requirements are tremendous and the analogy of an organization as an information processing system is well suited here.

In many ways NASA is in a better position to implement the Presidential directive than many other agencies. The fact that the space system acquisition processes deal with physical systems and their abstract counterparts is a big advantage over, let us say, the Department of Health, Education and Welfare. The concepts such as cost/effectiveness and the analytical and management methods involved in program budgeting have been used by NASA and its contractors. What is suggested here is that basic data and analysis concerning regional impacts be tied into this process.

Previously we commented on the communication aspect of information systems. In essence, the kinds of information and the forms in which it is presented—the communication aspect—should be determined through its uses by top management. Unless the basic data is tied into the decision-making process it is likely to remain a peripheral thing, not adequately utilized, and degenerate into a routine and unimaginative set of procedures. In addition, costing basic regional oriented data into such an overall framework means that it is consistent with the other data entering the program budgeting system.

## A Methodology for Projecting Regional Impacts

The basic hypotheses for the computational procedure are based on the analyses in Section III. They are:

1. That the major prime and subcontractor firms (value criterion) are overlapping and relatively few in number.

2. That the number of four digit manufacturing industries involved are again relatively few; and, that

the nonmanufacturing sectors involved are mainly in construction, engineering and technical consulting, and in computer services industries.

3. That the firms involved are concentrated (value criterion) in relatively few standard metropolitan statistical areas.

On the basis of the above we can specify three networks for prime and first-tier subcontractors.

1. <u>A geographic network</u> from point of origin (prime) to point of destination (first-tier subcontractor).
2. <u>A technological network</u> (PERT type) of the time-phased tasks (or products) required.
3. <u>An industrial network</u> from industry of origin to industry of destination. That is industrial classification of prime and industrial classification of subcontractor.

For each historical program or project in the program budget the primes and their subcontractors can be identified.[7] For future programs some conjecture as to alternative prime contractors is needed. In Section III we commented on the differential subcontracting patterns of the primes and how certain subcontractors appeared in the NASA tabulations for identical or similar tasks. Given the time-phased tasks required, which may be the basis of projected funding requirements, the alternative prime contractors can be considered and alternative choices of first-tier subcontractors computed.

These networks can be expressed in matrix form. Recast in this form one sees a set of time-phased input-output matrices (Markov chain) where each nonzero element is identified by task (product) or industry,

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7. The type of analysis described here was tentatively planned by UCLA under the present grant. The quality of current NASA data does not warrant such an analysis by an outside organization.

by geographic location and by a time parameter. This then is a time-phased regional model of the Leontief input-output class.

The aggregation of primes and their subcontractors yields a partial direct input-output column vector, again with time and geographic designations. The initial calculations can next be cojoined with an aggregative input-output matrix such as generated by the U.S. Department of Commerce; the missing direct and indirect industrial impacts can be computed. On the basis of classification, as "local" or "national," sources of supply could then be specified. Both time-phased models and regional models have been computed, but a time-phased regional model has not been published, if computed, in the United States.[8/] It must be noted that much of the output is based on "hard data" that could be generated by NASA. If desirable, the models could be expanded for local multipliers, e.g., income-consumption effects.

Some Characteristics of the Suggested Information System

Much of the data bits needed for the computational procedure outlined above is now in the NASA data banks in embryonic form, but not of the quality nor of the form necessary for computation. In Section II we discussed economic measurement problems of valuation (awards, obligations, expenditures), basis of classification (enterprise, industry, product), and appropriate geographic designation. The existing types of

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8. See: A. C. Hendrickson, et al., PEAM-1103A: An Economic Activity Model (TP-3) Research Analysis Corp., McLean, Va., (1963) and Wassily W. Leontief, et al., "The Economic Impact—Industrial and Regional—of an Arms Cut," The Review of Economics and Statistics, Harvard University Press, Cambridge, Mass., Vol. XLVII, No. 3 (August 1965).

NASA data must be evaluated in light of the above discussion. However, a merging of CEIS and the subcontractor reporting system opens some interesting possibilities.

The basic division of the data may be set by referring back to the statement that NASA impacts are transmitted geographically through external government, industry, and labor force. Following this triad, the programs and accompanying impact computation would separate intramural operations, procurement from industry (activities such as JPL would be included here), and university and other not-for-profit contracts and grants. (International transactions should be handled separately because of lack of direct domestic regional impacts.)

The proposed body of information has other properties:

1. It is relatively highly structured but open-ended.
2. It is future oriented.
3. Model structure and computional techniques would be built into the system.

The structure is derived from the program budget informational system and would be designed to fit into this framework. It is open-ended since, ex ante, it is not possible to specify all data needs or computational procedures. Conjecture enters into the system both because of statistical and real world uncertainties. But in any space plan there are innumerable uncertainties and the economic impact computations may be as "hard" as many other elements. Future plans as represented by planning numbers (which enter a program budget in the latter years of its time period) do not have a "hard" model of physical reality as an analogue. The inclusion of computational procedures for a model means that the intelligence system can be rapidly probed for alternative assumptions. It also means the editing routines may also be built into corporate changes.

Some Summary Remarks

An investigation into one data system, the subcontractor reporting system, and an attempt to analyze what has been collected in relation to regional effects has led us into other data systems within the space agency. The original cut was just too small a subsystem for what was attempted. Even the slightly better than cursory inspection given to other internal sources of data indicate that the agency collects and generates much information that could be used for evaluating economic effects. Yet, the data are in the stage of almost, but not quite. They lack two qualities of design: economic and statistical. Also lacking is cohesiveness and purpose. A suggested methodology was developed for the latter.

We also suspect that other influences are at work. Over the past twenty years, with the development of ever more powerful electronic computers and the development of techniques subsumed under management sciences, we are beginning to gain insights into the interactions between information and organizations; between both of them and decision-making processes; and the interface between technology and society. NASA is a mission-oriented agency predominately staffed by the "hard disciplines," engineering and the physical sciences (including mathematics). As a by-product of their efforts and management and control techniques, large quantities of socio-economic data are collected. Without an adequate "soft science" staffing the design of such information and its application is lacking.

One of the central themes in our thinking about NASA operations and data is the utilization of such information in the socio-economic sphere. We have emphasized only one phase, regional controversies and regional impacts. The space context within which the Agency operates is one which finds NASA operations as part of national science policy, national educational policy, fiscal policy, area income and employment policy (e.g., surplus labor area set-asides), and so on. Whether by design or not, the space agency is involved in nonspace missions, peripheral as they may seem. The central question (and the development and utilization of NASA generated data will depend on it) is whether NASA management desires to consider such side-effects in decision making and, if so, desires to develop a systematic way of developing the necessary information. To a large extent, the contribution of the academic community to NASA in the socio-economic field is also dependent on an overt and systematic information system designed for such purposes. Internal management problems are best handled by the agency.

## VI. SOME RECOMMENDATIONS CONCERNING NASA DATA

To this point there has been no statement on the costs involved in obtaining more relevant data for economic impact analyses. At times, perhaps, the previous discussions have verged on the pontifical with the inclusion of value laden terms like "need," "should," "requirement," and so forth. We are well aware that such terms do not mean that there is demand, in the economic sense, for such data. One with different objectives and values may well classify them as just "nice things to have" but not worth the cost. What would be a "nice thing to have" is a quantification of the social costs and benefits imputed to an economic information system such as described herein, or to an alternative. Such a benefit-cost analysis under the current state of the art may well be infeasible. It is a calculus similar to an effort to quantify the social costs and benefits of the civilian space program itself. In our discussions with NASA Headquarters staff we were advised to forego any cost estimates of any recommendations and leave such benefit-cost evaluation to the agency.

As mentioned previously, the main interest of the UCLA staff was in the subcontractor reporting system (Form 667), but in the application of the results of this reporting system it was necessary to place the data in a wider framework of NASA data. The recommendations below consequently are of two forms: some general ones for an integrated economic information system; and, specific ones relating to the subcontractor system.

No suggestions are made concerning internal organization or focal points of responsibility. We have described an organization such as NASA as subsystems linked together through an information network. Changes in the information and communication system may have an effect on the total organization. This is a matter of degree, and the degree of organizational impact is related to what may be done and how it is done.

The space agency has had task forces and individual consultants advise it on data for socio-economic analysis and the place and worth of such analysis in its operations. Some of what we have to say has been said before. To this extent, we want to reinforce previous suggestions:

1. <u>That the Administrator make it a matter of internal policy that the agency develop an integrated economic information system on a continual basis that is compatible with the program budget informational system</u>.

It is unlikely that an integrated economic information system would be developed unless two conditions are met.

(1) That the Administrator lend strong support to its development.

(2) That it be developed within a framework that gives conceptual guidance and, at the same time, a framework that is used in Agency decision making.

In the Introduction we commented on the considerations lying behind the fact-finding operations of the Federal Government. These were: first, the obligation of the government to base public policy on factual information, and, second, the obligation of the government to provide basic information to private individuals for guidance in their personal and business affairs. The integration of an economic information system into a planning-programming-budgeting framework would include both considerations. Such an integration also implies that NASA develop adequate projection methodologies for the time span covered.

2. <u>That the economic information system in its collection, processing, and internal use provide for both economic design and statistical design</u>.

In the preceding sections we mentioned the problems of economic design and statistical design in the measurement, collection, and use of economic data. The problem of economic design deals with what we want to know and how we go about amassing the facts. The problem of statistical design deals with ways of ascertaining and restricting errors of observation. In other words, there should be some certainty that what is measured is what was wanted and that the data are of adequate quality for their use. One major design criterion here is that the NASA generated data be capable of integration with other similar data in the Federal statistical system. Also, that NASA intramural and university and other not-for-profit operations be collected so as to be consistent with procurement and subcontractor data.

Other design specifications should include the following, among others:

1. The basic data should permit a one-to-one matching with:

    a. Program or project as defined in the program budget.

    b. Contractor name and number (prime and subcontractor where applicable).

    c. Place of performance (each separate location where work is carried on in a multi-establishment firm—that is, the establishment as the basic statistical unit).

    d. Federal Government standard codes, such as the Standard Industrial Classification, Census product codes, Standard Enterprise Classification, and standard manpower and occupational categories.

2. In addition to whatever is needed for management uses such as obligations and awards, actual expenditures or accrued costs should be tabulated for the specific time job period.

3. Regardless of the period for which data are collected, the information should be capable of being tabulated by quarters with the items applicable to that quarter.

4. One aspect of quality control for the user is the periodic revision and correction of historical information. This may be costly, but NASA should carry back major changes under some fixed criteria.

3. That NASA undertake a critical review and evaluation of its current reporting forms and other information with the objective of evaluating what changes are necessary in such reports and what new information is needed to provide an economic information system for the uses suggested herein.

Information is costly and one is impressed with the vast amount now being collected by the various parts of NASA. Before undertaking any extensive new data collection, it is preferable to see what can be done with existing data forms and procedures. The evaluation should also cover processing, quality control, and use. Such an evaluation may best be done by an internal group with advice of the Office of Statistical Standards, U.S. Bureau of the Budget.

In the development and continuation of its subcontractor reporting system (Form 667), NASA has performed an outstanding service to those concerned with geographic impacts of Federal purchases of goods and services. The subcontractor system has certain shortcomings, the more important of which have been noted in Section II. It also needs integrating with other internally generated information and in the wider field of economic measurement noted in points 1 to 3 above. Specific suggestions on the subcontractor data follow.

4. That the subcontractor data collection system (the "postal card" system) be continued, and that a reevaluation be undertaken of its purpose.

This reporting system appears to the onlooker as an appendage to the NASA reporting systems in that it apparently is not part of any program management system nor does it have a tie with agency decision making. It apparently was developed as a means of indicating to the public the spread of work beyond the prime contractor. This is a useful and legitimate purpose. However, the lack of quality controls; the ever expanding universe of primes with no overlay; and the failure to relate to other data may in large part stem from this purpose. NASA should consider the "postal card" system as an important input into its information and purposefully improve the data and make it consistent with other information generated by the Agency.

There should be no question of continuing an improved "postal card system." Consideration should be given to the possibilities of tying these data in with any move towards subcontractor reporting that may be developed by the Department of Defense. DOD, through the Office of the Assistant Secretary of Defense, Systems Analysis (Economics), has indicated a strong interest in the movements from prime to the ties of subcontractors and the possibility of some collection system.[1/] The advantages to the public of such compatibility would be great.

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1. See Economic Impact Analysis of Subcontracting Procurement Patterns of Major Defense Contractors, submitted to Deputy Assistant Secretary of Defense, Systems Analysis (Economics), (Contract DA-49-083 OSA 31160, by C-E-I-R, Inc., Bethesda, Maryland, September, 1966.

5. <u>That a critical review of the collecting and editing process be made</u>.

The reporting system as currently operated lacks adequate quality checks and review. The attempts at industrial classification described in Section II resulted in a lack of confidence in the adequacy of place of performance. Another type of probable error came to our attention in our attempt to compare JPL subcontracts of about $176 million, as reported in the NASA procurement report for FY 1964 with the $88 million reported in the "postal card" system for the same period. JPL explained the differences in the following manner.

1. JPL had failed to report a $61 million subcontract to Hughes on the surveyor program on form 667 but included it in its own subcontract figures.

2. JPL estimated that about 15 percent of its subcontracts (in this instance about $26 million) are omitted from the subcontractor reporting system because of size cut-off.

3. Another $6 million constituted modifications of original subcontracts let by JPL which were not reported on form 667, either because of size-limitations or other non-specified reasons. This despite the fact that modifications within the size cut-off are to be reported.

The check on adequacy of compliance with the instructions on form 667 may best be accomplished by NASA personnel visits to a sample of large prime contractors and large first-tier subcontractors to check on compliance with instructions.

Two other suggestions bear directly on quality control.

5a. <u>That the tabulations of January-June, 1962, be deleted from the series</u>.

The extent to which subcontracting was reported retroactively for the first six months of 1962 varies greatly between the original 12 primes covered. Lockheed and JPL reported no subcontracts, Boeing and Chrysler each reported one subcontract, and Ling-Temco-Vought presumably subcontracted $4.9 million in this period out of a corresponding prime award of $5.4 million. The inclusion of this period in the continuous series seems to confuse rather than clarify an analysis of geographic distribution. In several instances UCLA broke out the data by hand in order to clarify certain points.

5b. That the prime and subcontractors be classified by the Social Security Board industrial codes.

Such a matching—a carrying out of the experiment described in Section II will serve two purposes. (1) It will permit a review and evaluation of reporting compliance with place of performance instructions. (2) It will be a first step toward integrating NASA procurement data into the Federal statistical system.

6. That a separate tabulation, starting with FY 1963 for the original twelve reporting prime contractors, be provided.

The ever changing universe of prime contractors makes it impossible—without special tabulations (by hand if computer tapes are not accessible)—to study the subcontracting and geographic patterns of any fixed set of prime contractors. A continuous record of the original twelve reporting firms would provide such a universe and would permit analyses of how patterns may change in periods of both program expansion and contraction.

7. That a link between first- and second-tier subcontractors be provided.

Under current procedures, as reflected in NASA tabulations, first- and second-tier subcontracts are linked only to the prime contractor and not to each other. Consequently, it is not possible to trace the industrial and geographic flows from their point of origin to their point of destination. That is, the flows from the originating prime contractor through the first-tier and from first- to second-tier. Such a linkage is in order to completely identify the network of industrial and geographic activities. (Such a linkage may be provided through repeating item 7 in conjunction with reporting item 17 on the schedule—see Chart 2.)

8. <u>That the value of work performed be related to a definite time period</u>.

Both the prime and subcontractor award data as currently published are timeless. They are in "award time" not real time in that the value terms are for the undesignated contract time. Generally, economic data is gathered on a real time basis, such as monthly, quarterly, or annually. In this manner various statistical series can be utilized to describe and analyze a specific time period. This time relation is not possible with the subcontractor (prime contract) system. The NASA data refers to potential activity with no way for an analyst to relate it to real time. (In Section II there is a discussion of obligations, awards, etc.) NASA should identify either the estimated completion date of the award, or better yet, obtain actual expenditures or accrued costs for a definite time period.

There are several ways of handling such a problem. The award data should be kept since it serves an <u>ex</u> <u>ante</u> or anticipatory purpose. But the report form could request an estimated date of completion which could be followed by a request for actual completion date. NASA data on subcontractor accrued costs (Form 533) might be used in conjunction with the subcontractor award data (Form 667) to obtain some approximate aggregative time profiles for subcontractor activities. (Form 533 does not identify subcontractor location, however.) If uniform patterns (say, by task) could be developed, they could be applied to award data. What is really required, however, is an ex post report on the value of work performed, expenditures, or accrued costs. Such data may well require a follow-up reporting system.

9. That the reported task be identified (Schedule items 13 and 23) by use of nomenclature identical with, or similar to, that in the NASA financial management list of OSS and R & D detailed codes. [See "Agency-wide Coding Structure (NPC-300-4), NASA Financial Management Manuals, IV," plus change manuals.]

Previously, we have mentioned the advantages of Federal standardized product coding and the use of a task type classification in projection methods. Either of these would enhance the use of the subcontractor data. A task (activity) coding of subcontracts (primes also if feasible) would permit cross-tabulations relating subsystems and components to technology (tasks) to award data so as to emphasize such variables in relation to time, subcontractor, and geographic location. Such a coding is best performed as an in-house operation. In discussing the possibility of coding by Census product classes with the Bureau of the Census, we were advised that this, too, would be most expeditiously done by NASA.

10. That data processing procedures should provide for revisions in awards back to the original time period and also provide for changes in place of performance.

These two items are discussed in Section II.

11. That an experiment with relaxation of size cut-off rules in reporting be undertaken.

Currently, there are only informed guesses on the amounts omitted due to the cut-off provisions and, apparently, no information on their geographic distribution. We suggest that an experiment be run for four quarters in which the size restrictions on reporting be either eliminated or reduced. The results could be evaluated in relation to dollar value and geographic impacts and a decision reached whether to continue or not.

12. <u>That a tabulation of data by Standard Metropolitan Statistical Area be undertaken</u>.

The metropolitan area is a widely used geographic unit of analysis. The NASA data, now identified by place of performance (city) and state could readily be coded by the Federal standardized area for presentation purposes.

13. <u>That computer generated maps be used for summarizing the subcontractor data</u>.

We strongly recommend that NASA investigate the costs of computerized mapping for Congressional and procurement report purposes. The U.S. Bureau of the Census has such a computer program. What we visualize are maps indicating origin and destination, where the width of connecting lines could indicate relative size of flows. A graphic presentation is much more dramatic than a tabular one.

14. <u>That the subcontractor reporting universe be extended to cover NASA intramural activities</u>.

Such an extension would indicate the impact of subcontracting by including the industrial and geographic coverage of NASA's own activities.

In this period of tight Federal nondefense budgets and the uncertainties about NASA's post-Apollo missions, questions on the agency's regional impact may appear trivial. But, such impacts are not trivial to the areas involved or to those seeking entry into space activities. Budgetary and program changes may mean instability in income and employment to many locations. The implications of current events is that regional impacts may well become critical to the agency. For the longer run, the need for regional information continues for post-Apollo programs.